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AUGUST 22, 1988

CHEMICAL & ENGINEERING

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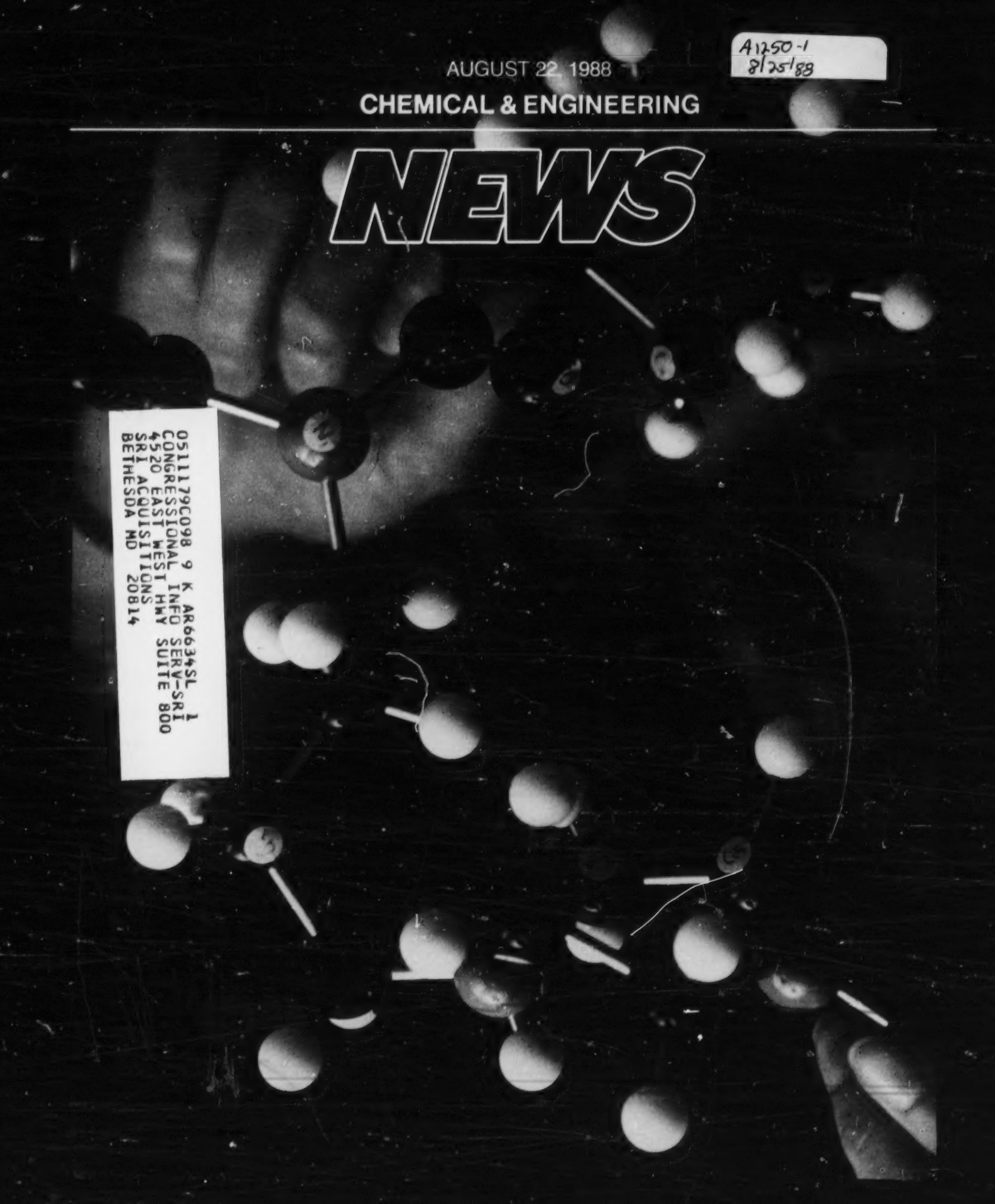

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CHEMICAL & ENGINEERING
NEWS
AUGUST 22, 1988

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News of the Week

■ **Cabot Corp. has adopted an antitakeover plan to deter possible acquisition by GAF and its feisty chairman, Samuel Heyman.** **Page 4**

■ **Synthetic enzymes that catalyze cleavage of target RNA molecules with high specificity have been developed by an Australian research team.** **Page 5**

■ **New report from a National Research Council panel states that better safety planning is needed in the Department of Energy's research reactor program.** **Page 5**

■ **Increased awareness and cooperation are needed to protect space missions from collisions with orbiting debris, say international space officials.** **Page 6**

■ **Discovery that atmospheric levels of two bromine-containing halocarbons are on the rise has intensified concerns about the ozone-destroying potential of these compounds.** **Page 6**

Cover: Photo courtesy of Bristol-Myers Co.

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Business

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Government

EPA has proposed four alternative approaches for regulating benzene emissions and is seeking public comment on how to proceed. **Page 22**

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Education

NSF official calls for commitment to improve the quality of U.S. science and engineering education, suggests need to head off predicted shortfalls in scientific manpower levels. **Page 26**

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Books

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ACS News

Council will act on three petitions—open meetings, emeritus status, and membership count for divisions—at its meeting in Los Angeles. **Page 69**

Special Report

C&EN's annual compilation of data on research and development reveals that U.S. chemical R&D is healthy and growing, with overall spending on R&D expected to reach $128 billion this year, up 7% over 1987. **Page 29**

Chemical & Engineering News

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LETTERS

Nonleaded gasoline

SIR: I would like to propose to all of our oil companies as well as the American Petroleum Institute, plus others, that the designation of unleaded gasoline on gasoline pumps at gasoline stations be changed to nonleaded gasoline.

The term unleaded is misleading. In teaching large classes of nonscience majors on the subject of energy and the story of gasoline, I always go 'round and 'round with my students, trying to explain that the lead in unleaded gasoline has not been removed from the gasoline—it was never added. We of course know, for example, that toluene and benzene are additives in unleaded gasoline to ensure smooth combustion.

Therefore, I strongly urge the use of the term nonleaded to replace unleaded. This will be a great favor to the general public.

Saul Barron
Emeritus Professor of Chemistry
State University of New York, Buffalo

Bond energy distinction

SIR: The brief account of the recent work of Emily Carter and William Goddard (C&EN, June 27, page 26) emphasizes the necessity of distinguishing carefully between "bond dissociation energy (BDE)" and "contributing bond energy (CBE)" when describing bond strength. The authors correctly identify their C=C bond energy as "D" (BDE) in their paper on C_2F_4. The C&EN item does not specify which kind, and one can only infer this from the mention of experimental determinations, which would here be impossible for CBEs.

Calculation of the contributing bond energies by the theory of polar covalence gives 105.4 kcal for the C—F bond and 154.5 kcal for the C=C bond, totaling 576.3 for the atomization energy of C_2F_4, the experimental value being 576.1. The C=C bond is not really "one of the weakest known." On the contrary, it is about 10 kcal stronger than the average C=C bond in alkenes, consistent with its shorter bond, 127 instead of 134 picometers. The reason it comes apart so easily is that when two CF_2 radicals are liberated from the double bond, their reorganization strengthens the C—F bonds. The energy released by this strengthening contributes to the dissociation of the C_2F_4, reducing the net requirement. It is not always possible to understand radical reorganizational energy, but here a reasonable explanation exists. Subtracting the authors' BDE of 64.5 kcal from the calculated contributing energy of 154.5 gives 90 kcal, which divided among the four C—F bonds adds 22.5 kcal to the energy of each. This is approximately the difference between the energy of a C—F bond calculated for complete lone pair bond weakening in the fluorine and that calculated for half-removal of the lone pair bond weakening in the fluorine. Thus the double bond in C_2F_4 is much easier to break than otherwise expected, possibly because the liberation of two half-filled orbitals per carbon atom somehow permits reduction of the lone pair bond weakening effect (LPBWE) on the homonuclear bond energy of the fluorine atoms. Additional understanding of LPBWE will be required for evaluating this suggestion. In fact, however, the authors' standard heat of formation of the CF_2 radical, −46.5 kcal, corresponds to a C—F bond energy therein of 127.8 kcal per mole of bonds, which is 22.4 kcal greater than in C_2F_4.

A BDE is the same as the CBE only for diatomic molecules. Otherwise it represents the sum of the CBE and the reorganizational energy of the liberated radical(s).

R. T. Sanderson
Fort Collins, Colo.

Periodic table long form

SIR: Joseph Lound-Keast (C&EN, Feb. 22, page 2) criticizes the choice of a numbering system of 1–18 of columns of the long form periodic table by the International Union of Pure & Applied Chemistry commission on inorganic chemistry [*Chem. Int.* **7,** 26 (1985); Busch, D. H., *Ibid.*, **9,** 49 (1987)]. He says, in part, that "it perpetuates the misconception of so many in the chemical profession, that, in some way, the periodic table has only 18 groups and two 'footnotes' of 14 elements that have to be 'squeezed' into the box alongside actinium and lanthanum."

In my opinion, assigning group numbers of 1–18, in addition to deprecating the 28 elements in the footnotes, suffers from a lack of significance of the numbers. Lound-Keast makes a very useful suggestion to remedy this: "The groups could be numbered according to the valence subshell; for example, the carbon group becomes the p2 group, the alkaline earths the s2 group . . . providing at first glance information about position and electronic structure" (after all, this is one major purpose of the periodic table). He goes on to advocate a "true" long form without footnotes.

In a paper published in the *Journal of*

pulled and laid into position. Akzo's Oostindiër thinks there is no engineering reason why a bridge could not span the English Channel instead of a tunnel and that the bridge cables might be made of para-aramid fibers. Du Pont also has promoted the fiber as a lightweight replacement for the toe in what are now steel-toed shoes, and in shoe soles for puncture proofing. It is pushing the fiber as a reinforcement in the heel and toe of socks to aid their durability.

Du Pont is also promoting the use of its meta-aramid Nomex fiber in combination with Kevlar. Kevlar adds dimensional stability and tear resistance whereas Nomex adds high-temperature resistance. The combination of the two fibers is useful in firemen's turnout coats and in airline seat covers. Du Pont has advanced to the point where the familiar yellow Kevlar may now be dyed. Green and black producer-colored Kevlar is now in the testing stage, says Du Pont's Neal.

"The Man in the White Suit" thus may now dress in yellow, green, or black. And perhaps Emgo U.S.A., the apparel company that attempted to offer the fashion-conscious urban guerrilla designer Kevlar clothes in 1982, may try it once again with some color. □

Canadian chemical profits continue to surge

At the year's halfway point, the Canadian chemical industry shows no signs that it is about to slow down. Strong demand and rising prices are helping Canadian chemical companies to chalk up record earnings.

Du Pont Canada, the largest of the three big publicly held chemical firms in Canada, says that its second-quarter results exceeded the record performance that it set in the first quarter. Union Carbide Canada's second-quarter earnings are double what they were in the same period last year. And a continued strong performance in the second quarter produced for Celanese Canada the highest quarterly net income in the company's history, as well as record-breaking first-half earnings.

Throughout most of the Canadian chemical industry, the story is the same. Strong domestic demand, a hefty export market, and higher prices are combining to embellish the bottom lines of most Canadian chemical companies.

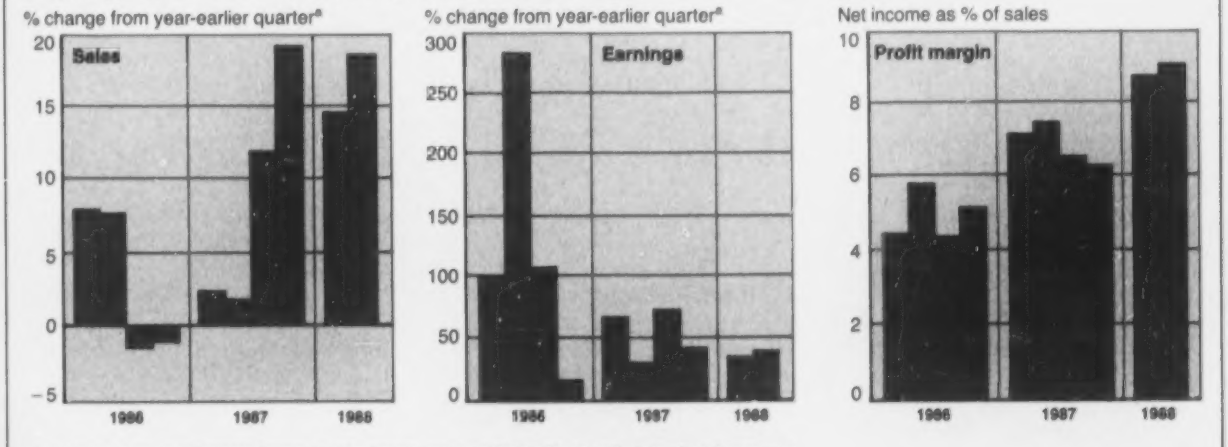
Chemical shipments in the first quarter ran 6% ahead of last year. But through the first four months of the year, chemical exports were a solid 25% higher than they were a year earlier. Exports of organic chemicals as well as synthetic rubber and plastics were a whopping 35% ahead of last year's pace. Even fertilizer exports, which have been lethargic for the past few years, were up 28% over the first four months of 1987.

The consequences of this surge are apparent in the first-half financial reports of Canadian chemical companies. For instance, the combined second-quarter sales of the three publicly traded Canadian chemical companies tracked by C&EN were $516 million (U.S. dollars; $1.00 = 1.230 Canadian dollars on June 30), up almost 19% on a Canadian dollar basis. Earnings were up an even stronger 42.8%. These companies include Celanese Canada, Du Pont Canada, and Union Carbide Canada. Earlier this year, the fourth publicly traded Canadian chemical company usually tracked by C&EN, C-I-L Inc., became a wholly owned subsidiary of ICI and stopped reporting quarterly earnings.

For the first six months, the combined sales of the three companies were $963 million, 16.7% higher than last year's first half. And net income increased an even stronger 41%.

Union Carbide Canada apparently has adapted well to its recent restructuring. Second-quarter net income was $9.2 million, up a staggering 102% over last year's similar period. Sales improved 46% to $120 million, and even after a change in accounting consolidation that the company adopted this year, growth in comparable sales was still ahead

Earnings growth continues to outpace sales growth



Note: Combined results of Celanese Canada, Du Pont Canada, and Union Carbide Canada. a Based on Canadian currency.

23%. Company chairman W. Norman Kissick says the increase "largely reflects higher selling prices in a current tight market."

For the first half, Union Carbide Canada's net income was $15.7 million, up 66% on sales ($223 million) that were ahead only 42% of the year-earlier period. Kissick notes that Pétromont, the Montreal-based producer of primary petrochemicals that Union Carbide Canada owns jointly with Société Générale de Financement du Québec, continued to be a major contributor to the improvement in Carbide's profits. In addition, the company's carbon products and its industrial, medical, and specialty gases chalked up significant gains.

Meanwhile, Celanese Canada is basking in its record second-quarter and first-half performances. Net income for the second quarter rose 79% to $10.2 million on a 19% sales increase to $84.9 million. For the first half, the company's net income gained 88% to $19.5 million, and its sales rose just under 20% to $161 million.

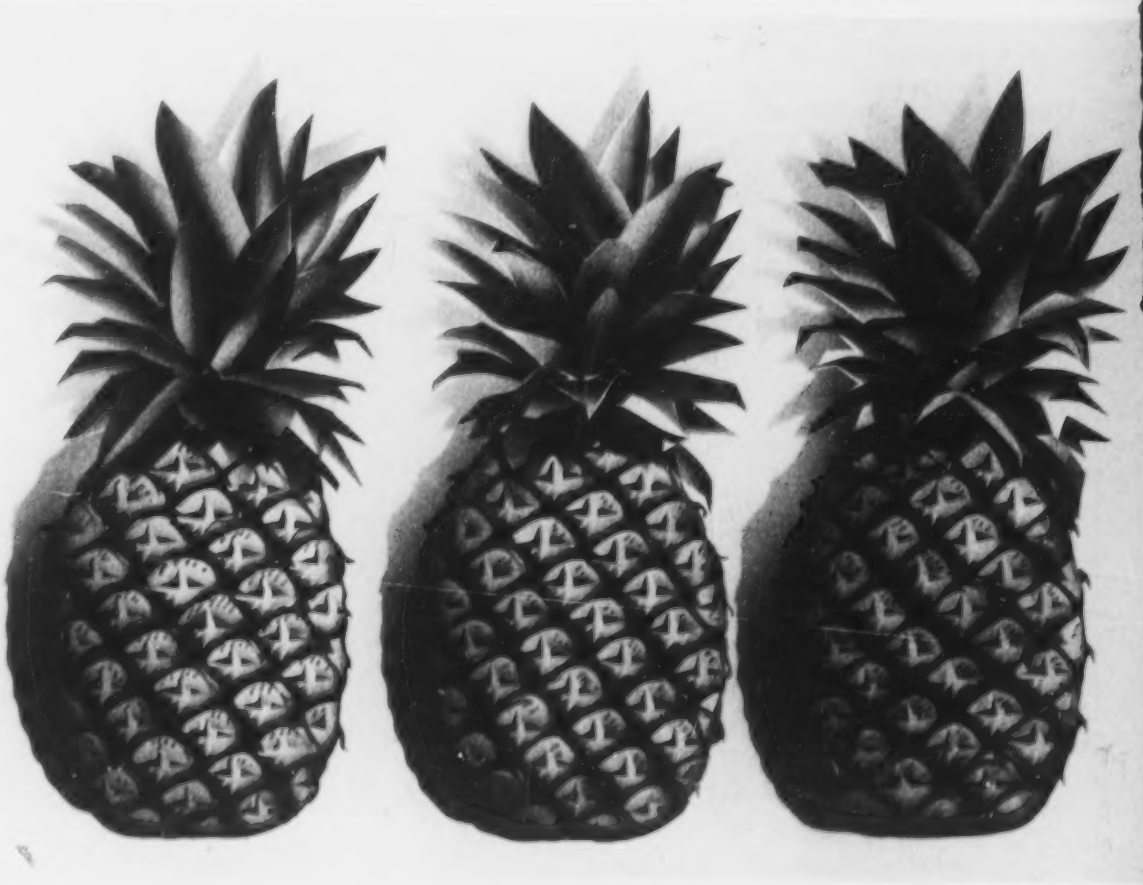
All of Celanese Canada's operating groups are contributing to the company's record-breaking year so far. In the textiles group, both the polyester staple fiber and heavy industrial fiber units are operating at capacity, although company president Paul H. Williams warns that substantial increases in raw materials prices are putting pressure on these businesses.

The cellulosic fiber unit also is operating at effective capacity. High-

Canadian chemical companies are enjoying a strong year

$ Millions[a]	Net sales	Change from 1987[b]	Net income[c]	Change from 1987[b]	Profit margin[d] 1988	Profit margin[d] 1987
			SECOND-QUARTER 1988			
Celanese Canada	$ 84.9	19.3%	$10.2	78.6%	12.0%	8.0%
Du Pont Canada	311.1	10.6	27.3	21.7	8.8	8.0
Union Carbide Canada	119.7	45.9	9.2	101.8	7.7	5.6
TOTAL	**$515.7**	**18.7%**	**$48.7**	**42.8%**	**9.1%**	**7.5%**
			FIRST-HALF 1988			
Celanese Canada	$161.2	19.6%	$19.5	88.4%	12.1%	7.7%
Du Pont Canada	579.2	8.6	50.6	23.4	8.7	7.7
Union Carbide Canada	222.5	41.6	15.7	66.1	7.1	6.0
TOTAL	**$962.9**	**16.7%**	**$85.8**	**41.1%**	**8.9%**	**7.4%**

a $1.00 = $1.230 Canadian (second quarter) and $1.249 Canadian (first half). b Based on Canadian currency. c Based on continuous operations and excluding extraordinary items. d Net income as percentage of sales.



er shipments and improved margins on exports are offsetting a softer domestic market, says Williams. In industrial products, cellulose acetate tow, which is used for cigarette filters, continues to be sold out, even though the company increased capacity during the second quarter.

Among chemicals, Celanese Canada finally benefited from a strong demand for methanol. As a result, the company was able to boost prices on the alcohol. Williams says that the balance of the company's chemical business was a "major contributor" to the company's profit picture, even though many products were hit with feedstock price increases.

Another record-setter in the Canadian chemical industry was Du Pont Canada. In the second quarter, net earnings were a record $27.3 million, 22% more than in the last year's second quarter. For the first half, earnings from operations hit $50.6 million, up 23% over last year's first half. Du Pont Canada was hurt by lower earnings from its carpet fiber business, but that was more than offset by higher sales volume and selling prices in other product lines.

Du Pont's sales were up 11% in the second quarter to $311 million and up 8.6% in the first half to $579 million. Sales of carpet fibers were down from last year's record levels and the company lost the revenue it used to receive from its explosives business that it sold in January. But Du Pont Canada's president J. Edward Newall says that sales of most other products were higher. Among the leading gainers: plastic resins, specialty packaging films, herbicides, automotive finishes, and hydrogen peroxide.

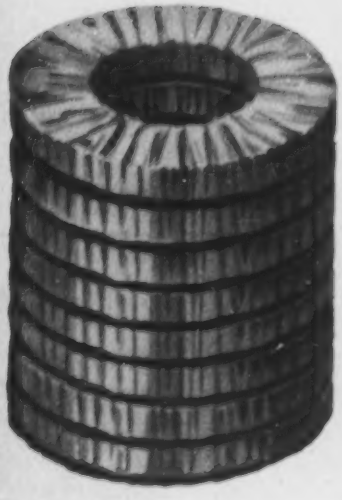
Can Canadian chemical companies continue the torrid pace that they have set so far this year? Many top executives in the industry think so. Du Pont Canada's Newall says that the outlook for the rest of the year looks good. Carbide Canada's Kissick thinks that the company's "positive performance trend" will continue for the rest of the year. And Celanese Canada's Williams believes that the outlook for the remainder of 1988 remains encouraging.

However, Williams hints at one possible trouble spot. He says that if the Canadian dollar continues to strengthen, it could hurt his company's export selling prices.

No doubt it could have an impact on the all-important exports of other Canadian chemical companies as well. In June, the Canadian dollar was worth 83.2 U.S. cents. In January 1986, it was worth only 70 U.S. cents. Recently, it has weakened to about 82 U.S. cents and many Canadian economists think that the rise in the Canadian dollar is over. If not, Canadian chemical exports—and Canadian chemical companies—could be in trouble.

Earl Anderson

The difference between our hydrazine and everyone else's.



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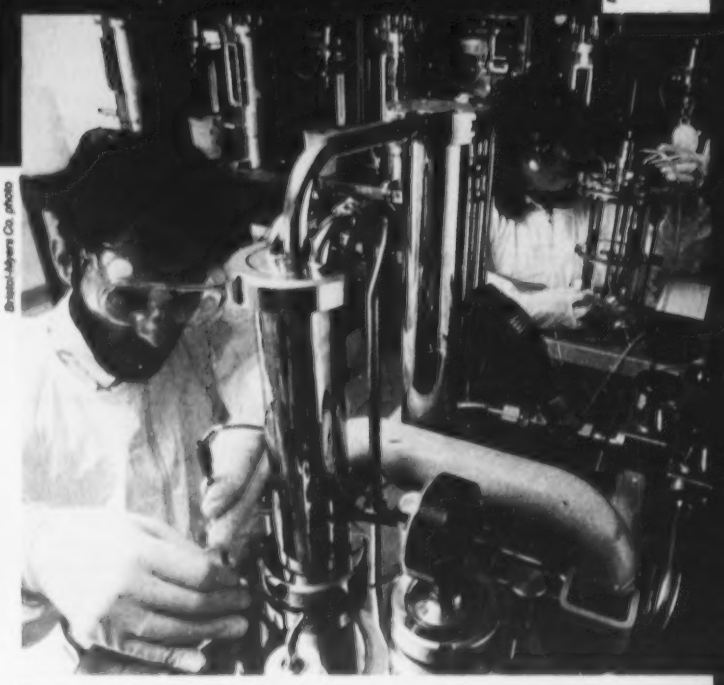

Bristol-Myers Co. photo

Facts & Figures for Chemical R&D

Rebecca L. Rawls, C&EN Washington

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R&D effort to reach $128 billion in 1988

Research and development in the U.S. is healthy and growing. Overall spending on R&D is expected to reach $128 billion this year, up 7% over last year. With inflation low—projected to be 3 to 4% for the year as a whole—R&D spending will rise at least 3% in 1988 in real terms.

That rate of expansion is about the same as last year's and considerably better than the meager 1% growth, after taking inflation into account, that R&D experienced in 1986. Though not up to the headier levels experienced earlier in the decade, when inflation-adjusted growth climbed as high as 8% per year, current levels nevertheless indicate genuine expansion of the country's R&D effort. Taken altogether, R&D spending over the past decade has been growing, in real terms, at a respectable 5% per year. During the 1970s, in contrast, the rate of growth was a mere 1% annually.

Jobs, too, in science and engineering are growing at a healthy rate. Data on employment lag a bit behind those dealing with spending, but in 1986 4.6 million men and women were working in science and engineering in the U.S., twice as many as in 1976. That represents a growth in jobs in these fields of 7% per year during the decade, a period when total civilian employment, by comparison, increased just 2% a year.

R&D also is doing well in relation to the rest of the U.S. economy. R&D spending in 1988 will represent about 2.6% of gross national product, a percentage that's been holding steady since 1985. A decade ago R&D was getting only 2.1% of GNP. And the share of GNP that is going into R&D has not been higher since 1969.

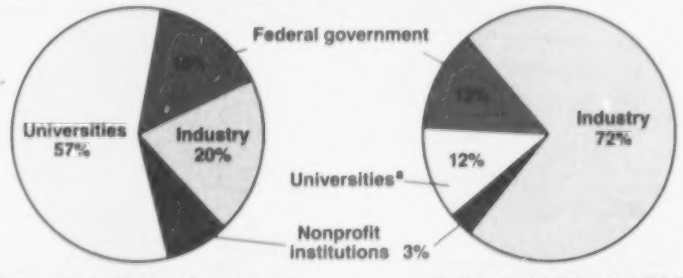
By any of several indicators, then, the R&D effort in the U.S. is steaming along pretty well. How it's faring in comparison with the R&D efforts of other countries is another question, and one for which figures are harder to come by. At a time of rapidly changing technology and increasingly stiffer global economic competition, concern for the ability of the U.S. to maintain a worldwide technological edge has never been greater.

Several countries that come to mind as potential competitors with the U.S. in high-technology markets spend as much or more of their GNP on R&D than the U.S. does. West Germany, for instance, has been steadily increasing the share of its GNP that supports R&D for the past decade, very much as the U.S. has, and spent an estimated 2.7% of its GNP on R&D in 1986, the latest year for which figures are available. Japan spent 2.8% of its GNP on R&D in 1985, the most recent year for which data are available for it.

In addition, because military budgets are relatively small in both West Germany and Japan, practically all their spending is for civilian R&D. In the U.S., on the other hand, defense-related R&D now accounts for a third of total outlays, up from only about 22% in 1980 to the highest level since 1970. Of total U.S. R&D spending, 63% is either nonfederal in origin or is for civilian-related work supported by the government, down from about 70% in the late 1970s and early 1980s. Consequently, civilian-related R&D's share of U.S. GNP is just 1.7%, well below that in either Japan or West Germany.

A look at patent activity suggests that both Japan and West Germany are significant competitors with the U.S. in chemical development. Of all U.S. patents issued last year in chemical technology, only about half went to U.S. applicants. Japanese applicants garnered 19% of the patents in this area, and West Germans received another 10%. West Germany has claimed about 10% of U.S. chemical patents every year for the past decade. Over the same period, Japan's share of these patents has grown steadily from its 1978 share of 11%. At the same time, U.S. patent holders' share of the total has dropped from 60% to 52%.

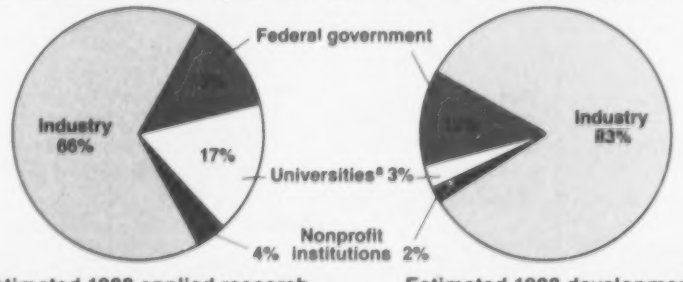
Although industry performs only one fifth of basic research, it does more than 70% of all R&D . . .



Estimated 1988 basic research spending = $15.3 billion

Estimated 1988 total R&D spending = $128 billion

. . . because it does the greater share of both applied research and development, where most money is spent



Estimated 1988 applied research spending = $26.5 billion

Estimated 1988 development spending = $86.4 billion

[a] Includes associated federally funded R&D centers.

Source: C&EN estimates based on data from the National Science Foundation

Last year, Japan's Fuji Photo ranked fifth among all companies receiving U.S. chemical technology patents. West German-owned Bayer was second, behind Dow Chemical, and two other West German companies—BASF and Hoechst—were also among the top 10. These three West German chemical companies, in fact, received nearly a third of all chemical patents issued during the past decade to the present top 10 recipients of such patents.

Just under half of all financial support for R&D in the U.S. comes from federal sources. Industry supplies almost all of the balance. But unlike many other areas of technology, chemistry and chemical engineering get very little government backing for R&D. Of the roughly $10 billion plowed into such R&D last year, about 90% was money from industrial firms, all but a quarter of it from firms in the overall chemicals and allied products industry, including pharmaceutical producers.

The relatively small amount of federal funds for chemical and chemical engineering R&D, moreover, has been expanding at a rather slow pace recently. This year's total of nearly $900 million will be down 5% from 1987 and is only 7% higher than spending three years ago.

Clearly, then, the health of chemical R&D is more dependent than that in most other science and engineering disciplines on support from industry—and, more specifically, from the chemical industry. R&D budgets of chemical firms also have been expanding less rapidly during the past few years. Last year, C&EN estimates, R&D outlays by the industry were up 10%, thanks largely to a 15% gain by drug companies; for producers of industrial chemicals, the increase was a more modest 8%. The year before, when the industry was wracked by drastic restructuring and cost-cutting programs, the increase was a mere 4%. During the late 1970s and early 1980s, on the other hand, with pharmaceutical producers again setting the pace, the industry increased its R&D spending at a 16%-a-year clip.

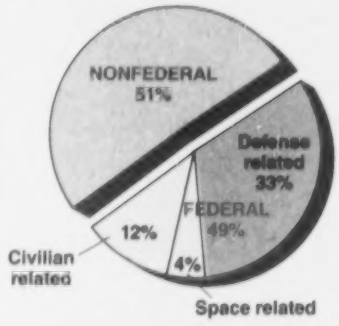
But the slow pace more recently should be viewed in perspective. Inflation in the past five years has been in the moderate 3- to 4%-a-year range, less than half the rate during the previous five years. If inflation is factored out, R&D spending by the chemical industry has been expanding at essentially a steady pace throughout the entire decade. This year, moreover, spending is likely to increase by about the same amount as it did in 1987.

Spending for chemical and chemical engineering research at universities also seems to be slowing. Outlays were up a mere 2% last year, after adjustment for inflation, compared with gains of 9% the two previous years. And because about 70% of university spending in these fields is from federal funds, the decline in government support of chemistry this year may seem disheartening to researchers in academic chemical labs. But the National Science Foundation, the major government source of funding for university R&D in chemistry and chemical engineering, will have 14% more money for all such R&D this year. In fact, more funds from NSF and the National Institutes of Health are boosting total federal funding of university chemical research 9%.

As employment in science and engineering expanded during the 1980s, some significant changes were taking place in the demographic makeup of the science community as well. Both women and minorities are more common in the scientific work force than they were a decade ago, for one thing, though only one minority group—Asians—is represented in anything approaching its proportion in the total population. Women comprised 15% of scientists and engineers in 1986, up from 8.5% in 1976. Nearly 29,000 women work as chemists—16% of the total—and another 11,000 as chemical engineers—8% of that group.

Only 2.5% of the scientific work force was black in 1986, but that's a relatively large gain from the 1.6% representation of this group in 1976. Among chemists and chemical engineers, however, where blacks were 2.0% of the work force in 1976, the proportion has remained unchanged. Asians held 5% of all science and engineering jobs in 1986, as they also did in 1976, and 7% of jobs in chemistry and chemical engineering. □

Federal defense spending is a third of all U.S. R&D

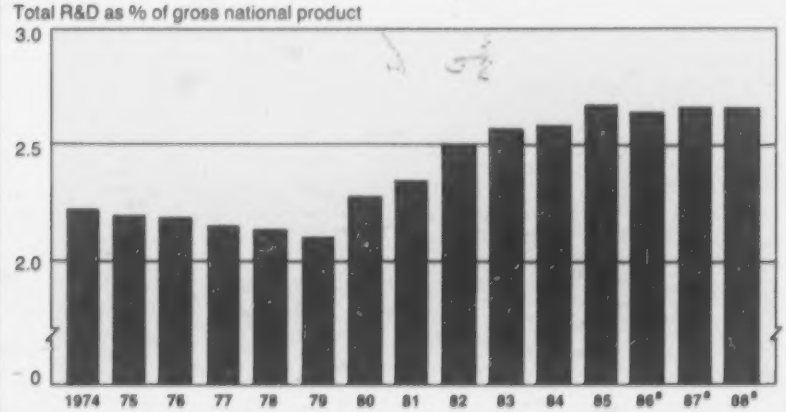


Estimated 1988 total R&D spending = $128 billion

Source: National Science Foundation

R&D share of U.S. GNP holds at high level

Total R&D as % of gross national product

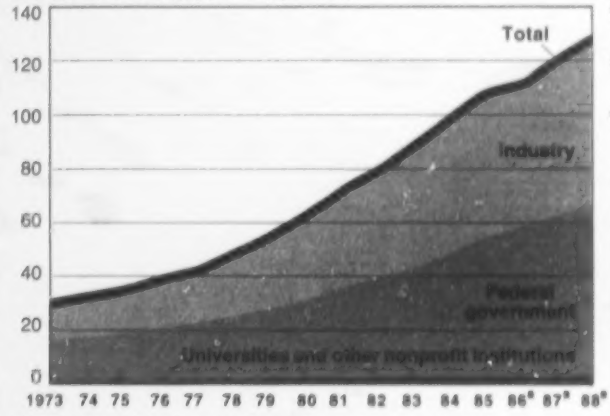


a C&EN estimates. Source: National Science Foundation

Growth in funding slows slightly

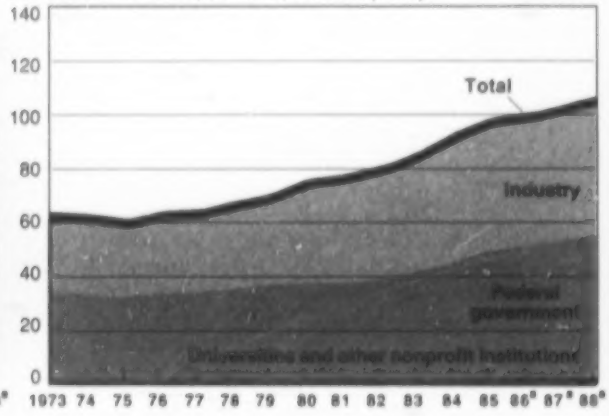
Overall U.S. R&D spending approaches $130 billion in 1988 . . .

Sources of R&D funds, $ billions, current



. . . and has outpaced inflation for more than a decade

Sources of R&D funds, $ billions, constant (1982)



a C&EN estimates. **Source:** National Science Foundation

SOURCES OF R&D FUNDS: Support from nearly all sectors is rising uniformly

$ Billions (current)	1988a	1987a	1986a	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Federal government	$ 63.4	$ 59.4	$ 54.3	$ 51.3	$45.3	$40.7	$36.5	$33.4	$29.5	$26.8	$23.9	7%	10%
Industry	60.4	56.6	53.5	52.6	49.1	43.5	40.1	35.9	30.9	26.1	22.5	7	10
Universities and colleges	2.9	2.7	2.5	2.3	2.0	1.9	1.7	1.5	1.3	1.2	1.0	7	11
Other nonprofit institutions	1.5	1.4	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	5	6
TOTAL	**$128.2**	**$120.1**	**$111.7**	**$107.4**	**$97.6**	**$87.2**	**$79.3**	**$71.8**	**$62.6**	**$54.9**	**$48.1**	**7%**	**10%**
ANNUAL CHANGE	**7%**	**8%**	**4%**	**10%**	**12%**	**10%**	**10%**	**15%**	**14%**	**14%**	**12%**		
$ Billions (1982, constant)													
Federal government	$ 52.2	$ 50.4	$ 47.8	$ 46.2	$42.1	$39.2	$36.5	$35.5	$34.4	$34.1	$33.1	4%	5%
Industry	49.7	48.1	47.0	47.4	45.6	41.9	40.1	38.2	36.1	33.2	31.2	3	5
Universities and colleges	2.4	2.3	2.2	2.1	1.9	1.8	1.7	1.6	1.5	1.5	1.4	4	6
Other nonprofit institutions	1.2	1.2	1.2	1.2	1.1	1.1	1.0	1.1	1.1	1.0	1.1	2	1
TOTAL	**$105.5**	**$102.0**	**$ 98.2**	**$ 96.8**	**$90.6**	**$83.9**	**$79.3**	**$76.4**	**$73.0**	**$69.8**	**$66.6**	**3%**	**5%**
ANNUAL CHANGE	**3%**	**4%**	**1%**	**7%**	**8%**	**6%**	**4%**	**5%**	**5%**	**5%**	**5%**		

Note: Constant-dollar values are calculated by C&EN based on NSF data. a C&EN estimates. **Source:** National Science Foundation

PERFORMERS OF R&D: Industry share, nearly three fourths of total, is fastest growing

$ Billions (current)	1988[a]	1987[a]	1986[a]	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Industry	$ 92.6	$ 86.1	$ 80.6	$ 78.2	$71.5	$63.4	$58.0	$51.8	$44.5	$38.2	$33.3	8%	11%
Federal government	16.4	15.5	13.5	12.9	11.6	10.6	9.1	8.4	7.6	7.4	6.8	6	9
Universities and colleges	11.7	11.2	10.6	9.5	8.5	7.8	7.3	6.8	6.1	5.4	4.6	5	10
University-associated FFRDCs[b]	3.9	3.8	3.6	3.5	3.1	2.7	2.5	2.5	2.2	1.9	1.7	4	9
Other nonprofit institutions	3.6	3.5	3.4	3.3	3.0	2.7	2.4	2.3	2.2	2.0	1.7	4	8
TOTAL	**$128.2**	**$120.1**	**$111.7**	**$107.4**	**$97.6**	**$87.2**	**$79.3**	**$71.8**	**$62.6**	**$54.9**	**$48.1**	7%	10%
$ Billions (1982, constant)													
Industry	$ 76.2	$ 73.2	$ 70.8	$70.5	$66.4	$61.0	$58.0	$55.1	$51.9	$48.6	$46.1	4%	5%
Federal government	13.5	13.2	11.9	11.6	10.8	10.2	9.1	8.9	8.9	9.4	9.4	2	4
Universities and colleges	9.6	9.5	9.3	8.6	7.9	7.5	7.3	7.2	7.1	6.9	6.4	2	4
University-associated FFRDCs[b]	3.2	3.2	3.2	3.2	2.9	2.6	2.5	2.7	2.6	2.4	2.4	1	3
Other nonprofit institutions	3.0	2.9	3.0	3.0	2.8	2.6	2.4	2.4	2.6	2.5	2.4	1	2
TOTAL	**$105.5**	**$102.0**	**$ 98.2**	**$96.9**	**$90.8**	**$83.9**	**$79.3**	**$76.3**	**$73.1**	**$69.8**	**$66.7**	3%	5%

Note: Constant-dollar values are calculated by C&EN based on NSF data. a C&EN estimates. b Federally funded R&D centers. **Source:** National Science Foundation

CHARACTER OF R&D: In real terms, research budgets stall while development funds increase

$ Billions (current)	1988[a]	1987[a]	1986[a]	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Basic research	$ 15.3	$ 14.9	$ 14.1	$ 13.1	$12.0	$11.0	$ 9.9	$ 9.2	$ 8.1	$ 7.3	$ 6.4	3%	9%
Applied research	26.5	25.4	24.1	24.6	22.2	20.4	18.5	16.9	14.1	12.3	10.8	4	9
Development	86.4	79.8	73.5	69.7	63.4	55.8	50.9	45.8	40.5	35.3	30.9	8	11
TOTAL	**$128.2**	**$120.1**	**$111.7**	**$107.4**	**$97.6**	**$87.2**	**$79.3**	**$71.8**	**$62.6**	**$54.9**	**$48.1**	7%	10%
$ Billions (1982, constant)													
Basic research	$ 12.6	$ 12.7	$ 12.5	$11.8	$11.1	$10.6	$ 9.9	$ 9.8	$ 9.5	$ 9.3	$ 8.9	−1%	4%
Applied research	21.8	21.5	21.2	22.2	20.6	19.6	18.5	18.0	16.5	15.6	15.0	1	4
Development	71.1	67.8	64.5	62.9	58.9	53.7	50.9	48.7	47.3	44.9	42.8	5	5
TOTAL	**$105.5**	**$102.0**	**$98.2**	**$96.8**	**$90.6**	**$83.9**	**$79.3**	**$76.4**	**$73.0**	**$69.8**	**$66.6**	3%	5%

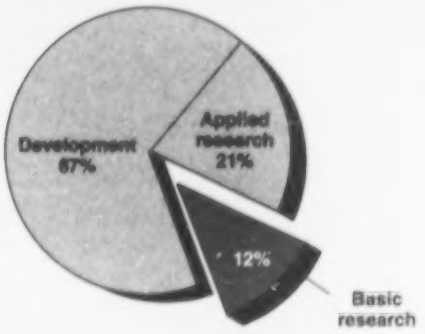
Note: Constant-dollar values are calculated by C&EN based on NSF data. a C&EN estimates. **Source:** National Science Foundation

EMPLOYED SCIENTISTS AND ENGINEERS: Women and minorities increase their participation

Thousands	1986 Total	1986 Women	1986 Blacks	1986 Asians	1986 Hispanic & others	1984 Total	1984 Women	1984 Blacks	1984 Asians	1984 Hispanic & others	1976[a] Total	1976[a] Women	1976[a] Blacks	1976[a] Asians
Scientists	**2186.3**	**599.6**	**73.7**	**94.0**	**56.4**	**1781.4**	**438.1**	**53.4**	**69.1**	**47.4**	**959.5**	**178.2**	**21.4**	**48.5**
Physical	288.4	38.3	6.2	15.4	5.8	254.1	28.3	6.1	12.5	5.4	188.9	16.2	3.2	7.6
Chemists	184.7	28.8	4.8	11.7	3.7	168.6	22.3	5.3	8.5	4.1	132.8	13.7	2.8	6.8
Mathematical and Computer	693.6	196.4	25.7	42.0	14.8	537.2	136.0	16.8	29.3	13.1	167.6	32.1	4.2	5.6
Environmental	111.3	12.9	1.0	2.1	2.2	98.1	10.3	0.6	1.8	2.1	54.8	3.9	2.0	3.2
Life	411.6	102.8	8.8	15.0	12.7	353.3	82.6	6.7	10.4	9.4	213.5	33.9	4.9	5.3
Psychologists and social scientists	681.3	249.2	32.0	19.4	20.9	538.7	180.8	23.2	15.1	17.4	334.8	92.2	7.1	26.8
Engineers	**2440.1**	**99.0**	**41.3**	**132.6**	**60.5**	**2214.1**	**74.5**	**37.1**	**117.5**	**59.5**	**1371.7**	**21.4**	**16.7**	**58.1**
Chemical	149.0	11.2	2.0	10.1	3.6	140.1	8.8	1.5	10.3	3.6	77.5	2.5	1.5	2.4
TOTAL[b]	**4626.5**	**698.6**	**114.9**	**226.6**	**117.0**	**3995.5**	**512.6**	**90.5**	**186.5**	**107.0**	**2331.2**	**199.7**	**38.1**	**106.6**

a Data not collected on Hispanic or other ethnic groups in 1976. b Detail may not add to total due to rounding. **Source:** National Science Foundation

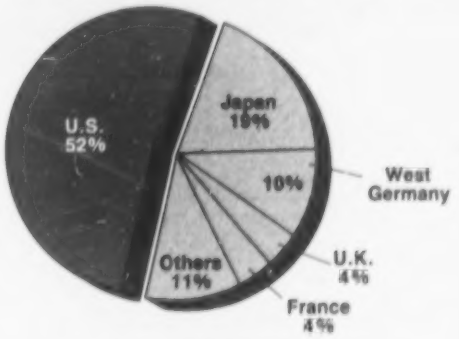
Basic research, the foundation for all R&D, claims only 12% of funds



Estimated total 1988 R&D spending = $128 billion

Source: National Science Foundation

Only about half of U.S. chemical patents go to U.S. firms or individuals



1987 total U.S. chemical patents issued = 21,374

Source: U.S. Patent & Trademark Office

PATENT ACTIVITY OF U.S. COMPANIES: Rebound in 1987 for both chemical and drug firms

Number of patents issued	1987	1986	1985	1984	1983	1982	1981	1980	1979[a]	1978	Total 1978–87
CHEMICAL COMPANIES											
Dow Chemical	469	371	335	328	246	276	260	249	217	334	3,085
Du Pont[b]	449	371	395	416	387	331	430	349	287	465	3,880
Ciba-Geigy	286	244	305	290	244	281	345	309	248	347	2,899
Union Carbide	159	208	242	231	182	202	262	211	197	215	2,109
PPG Industries	118	124	128	137	137	177	189	166	118	190	1,484
American Cyanamid	107	92	115	111	128	129	188	205	143	225	1,443
Stauffer Chemical	94	75	104	95	81	87	94	93	80	132	935
Monsanto	91	110	100	138	136	131	211	205	144	264	1,530
Celanese	66	66	67	94	57	56	58	56	44	71	635
Olin	58	81	117	112	85	80	80	106	82	99	900
Dow Corning	58	68	55	52	37	35	50	31	26	49	461
Hercules	50	43	41	39	37	30	52	23	24	49	388
Ethyl	48	77	105	76	44	31	43	51	25	41	541
W. R. Grace	43	42	45	57	52	49	68	72	56	76	560
International Flavors & Fragrances	38	76	104	95	87	87	96	76	60	80	799
Rohm & Haas	22	33	31	37	55	49	77	74	77	95	550
GAF	15	12	23	19	21	32	47	48	54	57	328
TOTAL[c]	**2171**	**2093**	**2312**	**2327**	**2016**	**2063**	**2550**	**2324**	**1882**	**2789**	**22,527**
ANNUAL CHANGE	**4%**	**−9%**	**0%**	**15%**	**−2%**	**−19%**	**10%**	**23%**	**−33%**	**6%**	
DRUG COMPANIES											
Merck	123	103	105	135	114	135	160	156	127	150	1,308
Warner-Lambert	118	101	73	49	34	25	37	36	36	59	568
Hoffmann-LaRoche	86	84	74	78	90	118	124	144	126	186	1,110
Eli Lilly	85	82	107	80	74	104	112	85	84	109	922
Squibb	75	70	74	53	37	56	62	85	98	136	746
Pfizer	67	72	72	89	61	72	92	75	65	89	754
SmithKline Beckman	54	27	43	68	59	66	59	82	71	117	646
American Home Products	46	38	49	32	24	43	52	52	39	67	442
Upjohn	26	66	66	107	73	122	337	170	196	344	1,507
TOTAL[c]	**680**	**643**	**663**	**591**	**566**	**741**	**1035**	**885**	**842**	**1257**	**8,003**
ANNUAL CHANGE	**4%**	**−8%**	**−8%**	**21%**	**−26%**	**−28%**	**18%**	**5%**	**−33%**	**15%**	

Note: Includes U.S. chemical and drug companies and U.S. subsidiaries of foreign companies that have received more than 1000 U.S. patents since 1962. a Patent figures were low in 1979 because the U.S. Patent & Trademark Office was short of funds to print patents. b Includes patents issued to Conoco, acquired in 1981, for all years. c These totals include patents issued to companies in this table only. Source: U.S. Patent & Trademark Office

COMPANIES OBTAINING U.S. CHEMICAL PATENTS: Five of top 10 are foreign corporations

Number of patents issued	1987	1986	1985	1984	1983	1982	1981	1980	1979[a]	1978	Total 1978–87
Dow Chemical	415	329	303	299	234	255	230	223	196	288	**2772**
Bayer	354	378	350	351	322	341	484	394	327	408	**3709**
Du Pont	336	268	283	291	273	240	288	241	183	302	**2705**
Ciba-Geigy	277	238	296	285	240	273	337	301	242	338	**2827**
Fuji Photo	252	251	258	180	126	125	181	124	98	125	**1720**
General Electric	248	247	316	277	273	251	304	257	205	287	**2665**
BASF	237	233	246	233	201	217	251	222	154	169	**2163**
Hoechst	217	211	214	202	202	190	236	212	187	272	**2143**
Mobil Oil	191	221	258	269	209	141	174	157	112	186	**1918**
Phillips Petroleum	161	177	225	233	222	174	211	213	176	229	**2021**
Exxon	157	191	243	213	189	167	214	181	190	229	**1974**
Union Carbide	138	169	203	178	151	171	218	177	150	175	**1730**
3M	128	127	126	92	93	105	115	73	61	89	**1009**
Merck	120	100	105	126	112	133	157	149	126	149	**1277**
Eastman Kodak	111	111	127	174	157	166	224	182	160	145	**1557**
Shell Oil	104	125	144	143	131	109	125	126	74	123	**1204**
Texaco	104	102	136	157	122	108	87	62	77	84	**1039**
PPG Industries	102	108	102	113	119	157	155	135	104	147	**1242**
TOTAL	**3652**	**3586**	**3935**	**3816**	**3376**	**3323**	**3991**	**3429**	**2822**	**3745**	**35675**
ANNUAL CHANGE	**2%**	**−9%**	**3%**	**13%**	**2%**	**−17%**	**16%**	**22%**	**−25%**	**−2%**	

Note: Includes patents issued in those technology subclasses that the U.S. Patent & Trademark Office classifies as chemical. [a] Patent figures were low in 1979 because the U.S. Patent & Trademark Office was short of funds to print patents. **Source:** U.S. Patent & Trademark Office

U.S. CHEMICAL PATENTS: 10% rise last year brings volume back to level of early 1980s

Number of patents issued	1987	1986	1985	1984	1983	1982	1981	1980	1979[a]	1978	Total 1977–86
U.S. origin	**11,208**	**10,408**	**11,430**	**11,377**	**10,470**	**10,557**	**12,619**	**11,157**	**9,234**	**12,887**	**111,347**
to U.S. corporations	9,714	9,117	10,078	10,001	9,067	9,135	10,911	9,605	8,037	11,308	96,973
to U.S. government	322	289	320	377	334	309	364	358	271	397	3,341
to individuals in the U.S.	1,031	910	977	923	974	1,011	1,274	1,116	866	1,099	10,181
to foreign-owned corporations in the U.S.	141	92	55	76	95	102	70	78	60	83	852
Foreign origin	**10,166**	**9,077**	**9,667**	**8,968**	**8,039**	**7,984**	**9,564**	**8,340**	**6,436**	**8,720**	**86,961**
to U.S.-owned corporations abroad	856	738	874	824	700	726	896	814	621	936	8,005
to foreign corporations	8,564	7,643	8,078	7,418	6,688	6,491	7,810	6,751	5,261	7,068	71,772
to foreign governments	197	150	163	167	132	165	100	96	78	85	1,333
to foreign individuals	549	526	552	559	519	602	758	679	476	631	5,851
TOTAL	**21,374**	**19,485**	**21,097**	**20,345**	**18,509**	**18,541**	**22,183**	**19,497**	**15,670**	**21,607**	**198,308**
% Foreign	**47.6%**	**46.6%**	**45.8%**	**44.1%**	**43.4%**	**43.1%**	**43.1%**	**42.8%**	**41.1%**	**40.4%**	**43.9%**

Note: Includes patents issued in those technology subclasses that the U.S. Patent & Trademark Office classifies as chemical. [a] Patent figures were low in 1979 because the U.S. Patent & Trademark Office was short of funds to print patents. **Source:** U.S. Patent & Trademark Office

HOLDERS OF U.S. CHEMICAL PATENTS: 8% of total shifts from U.S. to Japan since 1978

% of patents	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Total 1978–87
U.S. origin	**52**	**53**	**54**	**56**	**57**	**57**	**57**	**57**	**59**	**60**	**56**
Foreign origin[a]	**48**	**47**	**46**	**44**	**43**	**43**	**43**	**43**	**41**	**40**	**44**
Japan	19	19	18	16	15	14	13	12	11	11	15
West Germany	10	10	10	10	11	11	11	11	11	10	10
U.K.	4	4	4	4	4	4	4	5	4	5	4
France	4	3	3	3	3	4	4	4	4	4	3
Switzerland	2	2	2	2	2	2	2	3	3	2	2
Canada	1	1	2	1	1	1	1	1	1	2	1
Italy	1	1	1	1	1	1	1	2	1	1	1
Netherlands	1	1	1	1	1	1	1	1	1	1	1
Sweden	1	1	1	1	1	1	1	1	1	1	1
Belgium	1	1	1	1	—	1	1	1	1	1	1
U.S.S.R.	—	—	—	—	—	—	1	1	1	1	—

Note: Includes patents issued in those technology subclasses that the U.S. Patent & Trademark Office classifies as chemical. [a] Data for individual countries may not equal this number because of rounding. **Source:** U.S. Patent & Trademark Office

ABSTRACTS OF PAPERS IN *CHEMICAL ABSTRACTS:* Two fifths deal with biochemistry

	1987	1986	1985	1984	1983	1982	1977	Change 1977–87
BIOCHEMISTRY	40.5%	40.4%	40.5%	40.5%	38.3%	39.5%	37.9%	2.6%
% of all biochemistry abstracts								
Pharmacology	12.6	12.2	12.3	11.6	11.8	12.0	12.0	0.6
Mammalian hormones[a]	12.2	12.5	12.3	12.4	12.9	12.2	5.5	6.7
Mammalian biochemistry[a]	11.1	10.8	11.1	11.3	11.1	11.6	17.7	−6.6
Toxicology	8.3	7.8	7.9	8.0	8.5	8.1	6.2	2.1
Immunochemistry	5.8	6.1	5.3	4.8	4.2	4.4	3.1	2.7
Biochemical genetics[b]	6.7	6.1	5.2	4.2	3.8	3.3	—	—
Enzymes	5.4	5.6	5.6	5.8	6.1	5.9	6.1	−0.7
Plant biochemistry[a]	5.3	5.2	5.5	6.2	5.9	6.2	5.8	−0.5
Microbial biochemistry[a]	5.1	5.7	5.7	5.2	5.1	5.3	5.3	−0.2
Biochemical methods	4.8	5.0	4.9	4.9	4.9	4.6	5.1	−0.3
General biochemistry	4.6	4.7	4.9	5.3	5.8	6.0	7.0	−2.4
Others	18.1	18.3	19.3	20.3	19.9	20.4	26.2	−8.1
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
PHYSICAL, INORGANIC, AND ANALYTICAL CHEMISTRY	29.0%	29.6%	29.6%	28.8%	29.6%	28.5%	27.9%	1.1%
% of all physical, inorganic, and analytical chemistry abstracts								
Spectra	20.4	20.0	18.4	18.0	17.6	17.2	18.1	2.3
Nuclear chemistry	19.5	19.9	21.8	22.2	22.5	22.6	21.1	−1.6
Electric phenomena	10.9	10.8	10.8	10.8	10.0	10.5	10.5	0.4
General physical chemistry	7.9	7.0	6.9	6.9	7.3	7.3	6.8	1.1
Crystallography and liquid crystals	7.1	7.0	7.5	7.8	8.3	8.7	8.9	−1.8
Analytical chemistry	5.9	6.8	6.1	6.3	6.2	5.4	5.8	0.1
Others	28.3	28.5	28.5	28.0	28.1	28.3	28.4	−0.1
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
APPLIED CHEMISTRY AND CHEMICAL ENGINEERING	18.0%	18.2%	18.4%	17.6%	19.4%	19.5%	19.7%	−1.7%
% of all applied chemistry and chemical engineering abstracts								
Metals and alloys	20.6	20.8	20.0	18.9	19.1	22.2	24.2	−3.6
Water, wastes, and pollution	20.4	21.9	20.2	21.0	19.6	21.7	23.2	−2.8
Mineralogical and geological chemistry	11.2	12.0	12.5	14.6	14.1	13.6	13.4	−2.2
Fossil fuels, derivatives, and related products	9.6	9.0	10.1	10.1	10.3	9.4	9.2	0.4
Unit operations and processes	9.0	7.1	7.5	7.0	7.5	6.9	5.8	3.2
Pharmaceuticals and pharmaceutical analysis	7.8	8.2	8.0	7.0	6.5	6.3	5.6	2.2
Ceramics	6.3	5.8	5.6	5.1	5.4	4.5	4.1	2.2
Others	15.1	15.2	16.1	16.3	17.5	15.4	14.5	0.6
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
ORGANIC CHEMISTRY	6.9%	5.9%	6.4%	7.6%	7.3%	7.2%	8.8%	−1.9%
% of all organic chemistry abstracts								
Physical organic chemistry	23.9	27.3	30.6	32.0	30.5	31.5	41.3	−17.4
Heterocyclic compounds[a]	19.9	15.0	16.1	15.6	16.2	15.6	17.0	2.9
Organometallic and organometalloidal compounds	16.1	18.3	16.2	17.1	16.3	14.8	8.5	7.6
Aromatic compounds[a]	7.7	7.3	6.3	6.3	7.1	7.2	8.5	−0.8
Biomolecules and their synthetic analogs[b]	5.8	5.0	4.9	4.4	4.5	3.7	—	—
Carbohydrates	5.6	7.8	5.7	5.7	5.8	5.8	4.6	1.0
Aliphatic compounds[a]	4.9	4.4	4.2	3.6	4.3	5.2	5.9	−1.0
Amino acids, peptides, and proteins[a]	4.3	3.9	4.6	4.8	4.5	4.4	3.7	0.6
Others	11.8	11.0	11.4	10.5	10.8	11.8	10.5	1.3
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
MACROMOLECULAR CHEMISTRY	5.6%	5.7%	4.9%	5.5%	5.4%	5.3%	5.7%	−0.1%
% of all macromolecular chemistry abstracts								
Synthetic high polymers	35.2	34.1	34.1	34.0	34.4	34.7	26.5	8.7
Plastics manufacture and uses	23.6	23.8	25.3	24.2	24.4	21.9	27.5	−3.9
Cellulose, lignin, paper, and other wood products	8.8	9.8	9.1	9.6	9.1	9.7	10.0	−1.2
Textiles	8.1	8.8	8.2	7.3	7.9	8.9	11.0	−2.9
Synthetic elastomers and natural rubber	7.2	6.7	6.8	7.3	7.5	7.8	8.5	−1.3
Coatings, inks, and related products	5.8	7.2	7.2	7.8	6.6	7.6	7.5	−1.7
Others	11.3	9.6	9.3	9.8	10.1	9.4	9.0	2.3
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—

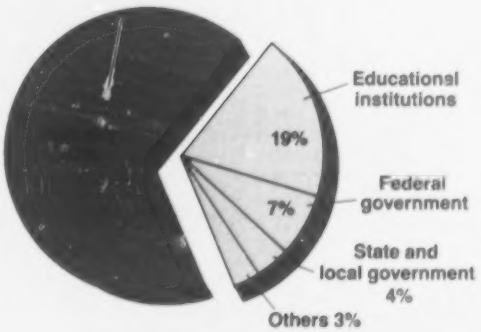
How to read this table: Using biochemistry as an example, 40.5% of all the papers abstracted by Chemical Abstracts Service are in the various subdisciplines of biochemistry; 12.6% of all abstracts in biochemistry, in turn, are in the subdiscipline of pharmacology, and so on. a Definition of section changed in 1982. b New section in 1982. **Source:** Chemical Abstracts Service

PRIMARY WORK OF SCIENTISTS AND ENGINEERS: 40% of chemists work in R&D

Thousands	Research & development				Management		Teaching	Consulting	Production & inspection	Reporting or computing	Sales	Professional services	Other[a]	TOTAL
	Basic research	Applied research	Development	Total	R&D	Total								
All scientists & engineers	**135.7**	**257.7**	**875.5**	**1268.9**	**398.6**	**1282.2**	**357.8**	**252.1**	**582.6**	**472.8**	**195.4**	**86.0**	**128.8**	**4626.5**
Industry	13.1	117.6	764.8	895.5	294.1	936.4	16.9	226.5	454.9	338.5	184.1	26.0	55.6	3134.5
Educational institutions	91.3	62.7	14.9	168.9	19.2	71.5	318.2	4.8	12.6	21.8	2.0	20.9	6.4	627.0
Federal government	17.2	44.3	56.7	118.3	51.4	127.5	5.8	7.1	53.8	53.8	2.7	1.9	11.1	382.0
State and local government	3.1	13.4	21.3	37.9	13.0	86.0	6.3	6.5	47.6	36.0	3.9	8.0	9.6	241.7
Nonprofit organizations	9.4	15.5	12.0	36.9	16.7	50.7	7.3	5.1	8.3	18.2	2.0	28.3	8.5	165.2
Other[a]	1.5	4.2	5.6	11.4	4.2	10.1	3.3	2.1	5.4	4.6	0.7	0.7	37.7	76.1
Chemists	**11.3**	**26.5**	**35.7**	**73.5**	**24.9**	**46.0**	**25.1**	**2.9**	**28.2**	**3.0**	**3.6**	**0.3**	**2.2**	**184.7**
Industry	2.4	18.9	33.6	54.9	20.4	37.2	0.5	2.9	21.3	1.9	3.5	na	0.8	122.9
Educational institutions	6.8	2.2	0.3	9.4	0.7	2.7	23.7	na	0.2	0.1	na	na	na	36.1
Federal government	1.6	2.8	1.5	5.9	2.5	3.6	na	na	2.6	0.5	na	0.3	0.1	13.0
State and local government	0.2	0.9	na	1.1	0.2	0.8	0.4	na	3.7	0.4	na	na	0.2	6.6
Nonprofit organizations	0.2	1.5	0.2	2.0	10.0	1.5	0.4	na	0.2	0.1	na	0.2	0.2	4.6
Other[a]	0.1	0.2	na	0.3	na	0.2	na	na	0.2	0.1	na	na	0.7	1.6
Chemical engineers	**1.2**	**7.3**	**42.8**	**51.3**	**15.4**	**50.5**	**3.5**	**7.1**	**22.8**	**5.0**	**4.5**	**na**	**4.4**	**149.0**
Industry	0.6	4.4	40.1	45.0	14.4	43.3	0.2	6.7	21.5	4.4	4.3	na	2.8	128.3
Educational institutions	0.5	1.8	0.3	2.6	na	1.2	3.3	na	na	na	na	na	0.1	7.2
Federal government	na	1.0	1.7	2.8	2.3	3.2	na	na	0.7	0.2	0.1	na	na	7.1
State and local government	na	na	0.2	0.2	0.1	1.0	na	na	0.3	0.3	na	na	0.1	1.9
Nonprofit organizations	0.1	0.1	0.3	0.4	1.5	1.7	na	0.4	na	na	na	na	0.1	2.6
Other[a]	na	0.1	0.2	0.3	na	na	0.1	na	0.2	na	na	na	1.2	1.9

Note: Based on 1986 survey. a Includes those not reporting. **Source:** National Science Foundation

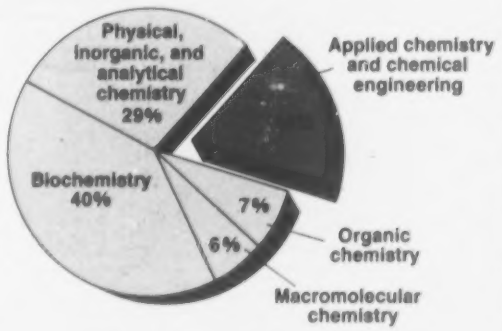
Two out of three chemists are employed by industry



Total chemists employed in 1986 = 184,700

Source: National Science Foundation

Nearly one fifth of chemistry papers are in applied chemistry fields

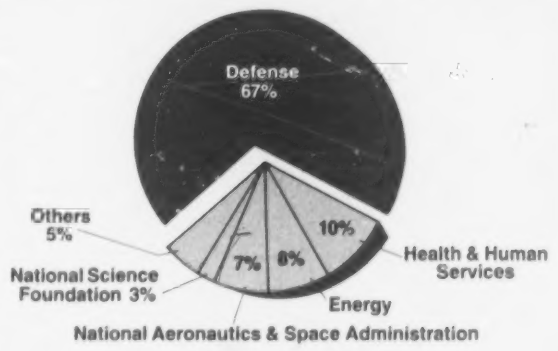


1987 total papers[a] = 476,178

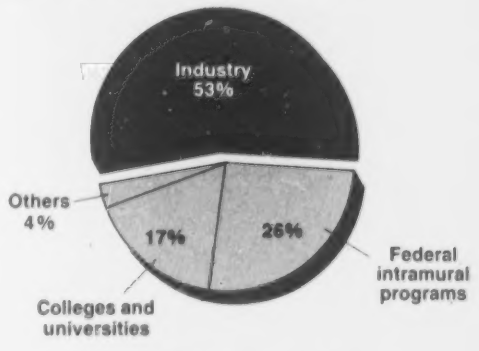
a Number of abstracts of papers published in *Chemical Abstracts*.
Source: Chemical Abstracts Service

Military spending sets the pace

Defense provides two thirds of federal R&D funding, industry gets over half of total



Estimated fiscal 1988 total federal R&D obligations = $63.4 billion



Estimated fiscal 1988 total federal R&D obligations = $63.4 billion

Source: National Science Foundation

FEDERAL OBLIGATIONS FOR R&D: Big gains for Defense and NSF offset declines elsewhere

$ Millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Defense	**$42,662.7**	**$36,243.9**	**$32,937.9**	**$29,791.5**	**$25,372.9**	**$22,992.8**	**18%**	**13%**
Air Force	18,688.0	15,759.7	13,593.8	13,260.9	12,091.6	10,812.6	19	12
Navy	10,562.6	9,503.1	9,650.3	9,127.4	7,605.6	6,068.2	11	12
Army	5,709.0	4,981.9	4,809.4	4,570.8	4,225.5	3,998.1	15	7
Defense agencies	7,416.5	5,833.3	4,767.4	2,781.7	1,391.5	2,052.3	27	29
Health & Human Services	**6,282.8**	**6,342.5**	**5,657.6**	**5,451.0**	**4,830.7**	**4,352.5**	**−1**	**8**
National Institutes of Health	5,576.3	5,557.2	5,005.1	4,827.7	4,257.4	3,789.2	0	8
Alcohol, Drug Abuse & Mental Health Administration	479.4	516.3	396.1	377.6	337.2	302.2	−7	10
Energy	**4,981.6**	**4,851.4**	**4,688.3**	**4,996.0**	**4,673.6**	**4,536.7**	**3**	**2**
National Aeronautics & Space Administration	**4,497.8**	**4,184.6**	**3,419.8**	**3,327.2**	**2,821.9**	**2,661.6**	**7**	**11**
National Science Foundation	**1,705.7**	**1,462.7**	**1,353.3**	**1,345.6**	**1,202.8**	**1,062.0**	**17**	**10**
Agriculture	**962.5**	**978.9**	**928.5**	**943.0**	**866.2**	**847.6**	**−2**	**3**
Agricultural Research Service	526.5	489.1	463.4	469.7	451.3	443.4	8	3
Cooperative State Research Service	238.3	288.8	269.0	284.3	235.7	232.3	−17	1
Forest Service	122.2	125.6	113.3	113.1	108.4	107.7	−3	3
Interior	**371.0**	**404.8**	**385.2**	**391.7**	**410.9**	**382.5**	**−8**	**−1**
Geological Survey[b]	217.4	223.1	218.6	214.9	208.9	157.0	−3	7
Environmental Protection Agency	**345.7**	**329.2**	**317.3**	**320.4**	**261.2**	**240.7**	**5**	**8**
Commerce	**328.1**	**407.6**	**399.2**	**398.8**	**358.2**	**335.0**	**−20**	**0**
National Oceanic & Atmospheric Administration	208.5	288.5	274.7	269.8	244.3	222.0	−28	−1
National Bureau of Standards	106.2	100.2	100.8	100.5	95.5	95.0	6	2
Others	**1,258.9**	**1,286.0**	**1,325.3**	**1,367.1**	**1,426.5**	**1,300.1**	**−2**	**−1**
TOTAL	**$63,396.8**	**$56,491.6**	**$51,412.4**	**$48,332.3**	**$42,224.9**	**$38,711.5**	**12%**	**10%**
ANNUAL CHANGE	**12%**	**10%**	**6%**	**14%**	**9%**	**6%**		

Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. Source: National Science Foundation

PERFORMERS OF FEDERALLY FUNDED RESEARCH: Industry's share is growing fastest

Federal obligations, $ millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Industry	**$34,006.6**	**$28,638.6**	**$26,205.6**	**$23,759.5**	**$20,361.5**	**$18,649.0**	**19%**	**13%**
FFRDCs[b] administered by industry	1,817.2	1,805.3	1,697.0	1,790.8	1,608.4	1,501.2	1	4
Federal intramural programs	**16,371.2**	**15,396.7**	**13,533.4**	**12,998.4**	**11,572.3**	**10,581.9**	**6**	**9**
Universities and colleges	**10,481.3**	**9,762.8**	**9,019.1**	**8,892.4**	**7,890.0**	**7,232.2**	**7**	**8**
FFRDCs[b] administered by universities	2,702.8	2,528.3	2,439.8	2,534.9	2,324.9	2,265.8	7	4
Nonprofit institutions	**2,185.1**	**2,261.0**	**2,228.1**	**2,388.4**	**2,094.4**	**1,822.9**	**−3**	**4**
FFRDCs[b] administered by nonprofit institutions	702.4	646.2	552.6	689.2	597.1	581.3	9	4
Foreign	**241.2**	**237.6**	**296.3**	**244.5**	**175.8**	**239.5**	**2**	**0**
State and local governments	**111.5**	**143.2**	**128.4**	**129.4**	**130.9**	**186.0**	**−22**	**−10**
TOTAL	**$63,396.8**	**$56,491.6**	**$51,412.4**	**$48,359.6**	**$42,224.9**	**$38,711.5**	**12%**	**10%**

Note: Fiscal years. a Estimated. b Federally funded R&D centers. **Source:** National Science Foundation

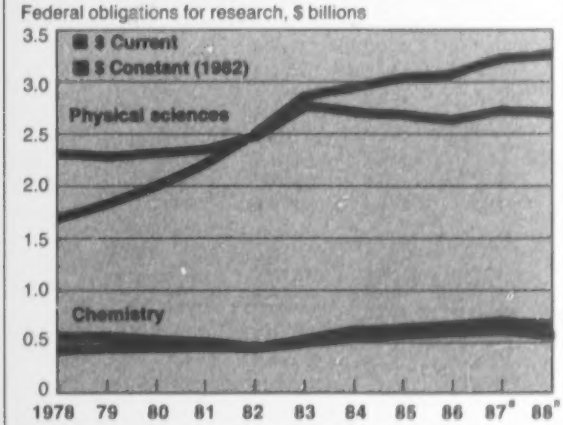
FEDERAL OBLIGATIONS FOR SCIENTIFIC DISCIPLINES: No gain for chemistry

$ Millions for research only	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Life sciences	**$ 7,092.2**	**$ 7,078.4**	**$ 6,464.3**	**$ 6,366.2**	**$ 5,635.9**	**$ 5,177.9**	**0%**	**6%**
Engineering	**3,976.3**	**3,978.6**	**3,738.9**	**3,628.5**	**3,624.1**	**3,517.0**	**0**	**2**
Chemical	201.1	248.8	245.8	254.1	144.5	145.0	−19	7
Metallurgy and materials	459.9	450.1	445.0	439.1	341.1	332.5	2	7
Physical sciences	**3,344.0**	**3,270.0**	**3,069.1**	**3,044.0**	**2,969.0**	**2,891.4**	**2**	**3**
Chemistry	692.0	696.0	662.4	644.5	606.4	520.3	−1	6
Physics	1,985.7	1,886.8	1,805.9	1,820.0	1,836.4	1,854.6	5	1
Environmental sciences	**1,626.3**	**1,553.2**	**1,481.7**	**1,403.6**	**1,275.9**	**1,251.2**	**5**	**5**
Mathematics and computer sciences	**688.1**	**654.5**	**615.4**	**577.5**	**440.3**	**419.4**	**5**	**10**
Other sciences	**1,278.4**	**1,277.4**	**1,132.8**	**1,110.3**	**1,033.6**	**996.6**	**0**	**5**
TOTAL	**$18,005.3**	**$17,812.0**	**$16,502.2**	**$16,130.1**	**$14,978.8**	**$14,253.5**	**1%**	**5%**
ANNUAL CHANGE	**1%**	**8%**	**2%**	**8%**	**5%**	**9%**		

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

Federal support for physical sciences and chemistry holding steady in real dollars

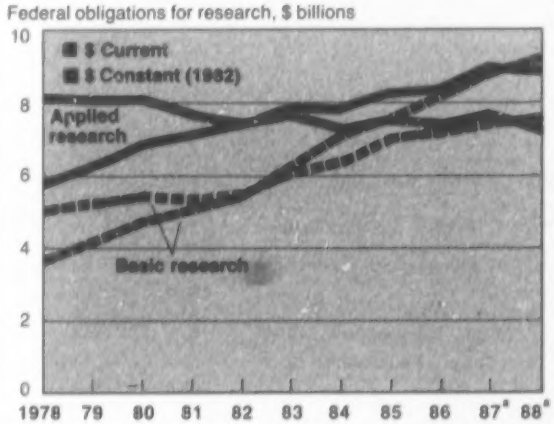
Federal obligations for research, $ billions



Note: Fiscal years. a Estimated. **Source:** National Science Foundation

In real terms, applied research support declines, basic research growth stalls

Federal obligations for research, $ billions



Note: Fiscal years. a Estimated. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR BASIC RESEARCH: NSF posts biggest gain in recent years

$ Millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987-88	Annual change 1983-88
Health & Human Services	**$3705.9**	**$3661.0**	**$3338.8**	**$3232.5**	**$2814.5**	**$2475.4**	**1%**	**8%**
National Institutes of Health	3446.2	3384.3	3118.6	3018.0	2624.8	2313.0	2	8
Alcohol, Drug Abuse & Mental Health Administration	239.7	256.7	203.4	196.8	170.8	145.0	−7	11
National Science Foundation	**1605.9**	**1378.3**	**1275.2**	**1261.8**	**1132.3**	**999.1**	**17**	**10**
Energy	**1140.0**	**1078.3**	**959.7**	**942.6**	**830.4**	**767.7**	**7**	**8**
National Aeronautics & Space Administration	**1015.5**	**1068.8**	**916.7**	**750.9**	**754.5**	**617.0**	**−5**	**10**
Defense	**910.4**	**861.2**	**923.9**	**861.4**	**847.9**	**785.6**	**6**	**3**
Navy	379.6	342.0	337.3	343.1	315.8	305.4	11	4
Air Force	225.2	205.1	216.5	198.3	192.4	164.2	10	7
Army	202.6	208.0	248.5	240.8	222.1	208.3	−3	−1
Defense agencies	103.0	106.1	121.7	79.2	117.6	107.7	−3	−1
Agriculture	**454.6**	**454.6**	**432.9**	**445.4**	**392.6**	**362.0**	**0**	**5**
Agricultural Research Service	281.6	261.6	247.7	250.2	240.6	215.3	8	6
Cooperative State Research Service	117.8	135.5	131.7	141.5	99.6	98.8	−13	4
Forest Service	46.4	47.7	42.2	44.1	41.2	38.8	−3	4
Interior	**123.0**	**140.9**	**133.0**	**138.3**	**125.9**	**103.0**	**−13**	**4**
Geological Survey[b]	83.1	83.7	83.4	80.5	78.9	64.7	−1	5
Environmental Protection Agency	**38.5**	**38.4**	**38.5**	**38.6**	**29.6**	**22.2**	**0**	**12**
Commerce	**23.9**	**23.8**	**26.5**	**23.2**	**20.6**	**19.2**	**0**	**4**
National Bureau of Standards	23.3	23.3	25.7	22.1	20.2	18.4	0	5
National Oceanic & Atmospheric Administration	0	0	0	0	0	0	—	—
Others	**116.4**	**130.8**	**107.1**	**124.0**	**119.1**	**108.9**	**−11**	**1**
TOTAL	**$9134.1**	**$8821.1**	**$8153.1**	**$7818.7**	**$7067.4**	**$6260.1**	**4%**	**8%**
ANNUAL CHANGE	**4%**	**8%**	**4%**	**11%**	**13%**	**14%**		

Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR APPLIED RESEARCH: No net gain despite defense increase

$ Millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987-88	Annual change 1983-88
Defense	**$2455.9**	**$2333.9**	**$2303.3**	**$2306.9**	**$2200.7**	**$2437.0**	**5%**	**0%**
Army	645.2	613.6	578.8	582.6	486.7	485.3	5	6
Air Force	600.0	504.5	542.5	538.4	547.7	524.2	19	3
Navy	458.7	419.6	447.1	448.2	449.6	521.6	9	−3
Defense agencies	752.0	796.1	735.0	737.7	716.6	905.9	−6	−4
Health & Human Services	**2072.0**	**2160.2**	**1850.8**	**1795.8**	**1651.5**	**1545.4**	**−4**	**6**
National Institutes of Health	1628.3	1694.9	1469.0	1410.1	1285.6	1165.2	−4	7
Alcohol, Drug Abuse & Mental Health Administration	238.1	257.4	191.5	179.7	165.2	155.4	−8	9
National Aeronautics & Space Administration	**1494.7**	**1410.6**	**1152.3**	**1032.7**	**954.7**	**927.8**	**6**	**10**
Energy	**920.9**	**1072.4**	**1080.7**	**1198.4**	**1194.5**	**1193.4**	**−14**	**−5**
Agriculture	**472.6**	**490.7**	**463.5**	**465.6**	**442.2**	**455.5**	**−4**	**1**
Agricultural Research Service	214.3	199.1	188.3	191.6	183.7	202.6	8	1
Cooperative State Research Service	120.4	153.3	137.4	142.8	136.2	133.5	−21	−2
Forest Service	72.2	74.3	67.5	65.7	63.9	65.1	−3	2
Commerce	**251.7**	**329.1**	**312.9**	**301.0**	**276.1**	**265.6**	**−24**	**−1**
National Oceanic & Atmospheric Administration	170.2	253.2	237.5	224.4	197.7	188.9	−33	−2
National Bureau of Standards	71.9	66.6	63.5	64.5	63.5	63.1	8	3
Interior	**230.3**	**244.0**	**234.9**	**231.0**	**254.3**	**254.7**	**−6**	**−2**
Geological Survey[b]	124.1	129.2	127.8	130.0	125.1	89.9	−4	7
Environmental Protection Agency	**167.9**	**171.2**	**179.3**	**176.0**	**142.3**	**152.4**	**−2**	**2**
National Science Foundation	**99.8**	**84.4**	**78.1**	**83.8**	**70.5**	**62.9**	**18**	**10**
Others	**705.3**	**694.4**	**693.2**	**720.3**	**724.6**	**698.7**	**2**	**0**
TOTAL	**$8871.2**	**$8990.9**	**$8349.1**	**$8311.5**	**$7911.4**	**$7993.4**	**−1%**	**2%**
ANNUAL CHANGE	**−1%**	**8%**	**0%**	**5%**	**−1%**	**6%**		

Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR DEVELOPMENT: Defense, NASA, and EPA all rise substantially

$ Millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Defense	**$39,296.5**	**$33,048.9**	**$29,710.7**	**$26,623.2**	**$22,324.3**	**$19,770.1**	**19%**	**15%**
Air Force	17,862.8	15,050.1	12,834.8	12,524.3	11,351.5	10,124.2	19	12
Navy	9,724.2	8,741.5	8,865.9	8,336.1	6,840.2	5,241.2	11	13
Army	4,861.2	4,160.2	3,982.1	3,747.4	3,516.8	3,304.5	17	8
Defense agencies	6,561.6	4,931.1	3,910.7	1,964.8	557.3	1,036.7	33	45
Energy	**2,920.7**	**2,700.6**	**2,648.0**	**2,825.0**	**2,648.7**	**2,575.6**	**8**	**3**
National Aeronautics & Space Administration	**1,987.6**	**1,705.2**	**1,350.8**	**1,543.6**	**1,112.7**	**1,116.8**	**17**	**12**
Health & Human Services	**504.8**	**521.2**	**468.0**	**422.7**	**364.7**	**331.7**	**−3**	**9**
National Institutes of Health	501.9	477.9	417.5	399.6	347.0	311.0	5	10
Alcohol, Drug Abuse & Mental Health Administration	1.6	2.2	1.2	1.1	1.2	1.8	−25	−2
Environmental Protection Agency	**139.3**	**119.5**	**99.5**	**105.8**	**89.2**	**66.1**	**17**	**16**
Commerce	**52.5**	**54.7**	**59.7**	**74.6**	**61.5**	**50.2**	**−4**	**1**
National Oceanic & Atmospheric Administration	38.3	35.3	37.2	45.4	46.6	33.1	9	3
National Bureau of Standards	11.0	10.3	11.6	14.0	11.8	13.6	6	−4
Agriculture	**35.4**	**33.5**	**32.1**	**32.0**	**31.3**	**30.0**	**6**	**3**
Agricultural Research Service	30.6	28.4	27.4	27.7	27.0	25.5	8	4
Forest Service	3.6	3.8	3.6	3.3	3.3	3.8	−3	−1
Interior	**17.7**	**19.9**	**17.3**	**22.4**	**30.7**	**24.8**	**−11**	**−7**
Geological Survey[b]	10.2	10.3	7.4	4.4	4.9	2.3	−1	35
National Science Foundation	**0**	**0**	**0**	**0**	**0**	**0**	**—**	**—**
Others	**437.1**	**476.1**	**524.0**	**552.8**	**583.0**	**492.7**	**−8**	**−2**
TOTAL	**$45,391.5**	**$38,679.6**	**$34,910.2**	**$32,202.1**	**$27,246.1**	**$24,458.0**	**17%**	**13%**
ANNUAL CHANGE	**17%**	**11%**	**8%**	**18%**	**11%**	**4%**		

Note: Fiscal years. a Estimated. b Includes Office of Water Research and Technology. **Source:** National Science Foundation

UNIVERSITY RESEARCH: Engineering gets a big boost, chemistry also does well

Federal obligations, $ millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Life sciences	**$3814.8**	**$3575.2**	**$3251.8**	**$3192.2**	**$2800.2**	**$2460.0**	**7%**	**9%**
Physical sciences	**851.2**	**786.6**	**751.9**	**749.7**	**697.8**	**596.5**	**8**	**7**
Chemistry	308.3	282.9	265.7	266.8	242.3	205.7	9	8
Physics	444.8	413.4	404.7	401.8	375.2	328.8	8	6
Engineering	**675.2**	**590.2**	**609.0**	**507.1**	**474.2**	**408.7**	**14**	**11**
Chemical	55.9	52.4	51.1	45.6	51.2	23.6	7	19
Metallurgy and materials	152.4	126.7	133.3	107.2	87.7	86.0	20	12
Environmental sciences	**437.9**	**386.8**	**365.7**	**361.1**	**319.5**	**316.9**	**14**	**7**
Mathematics and computer sciences	**320.9**	**292.8**	**273.9**	**253.1**	**181.6**	**172.4**	**10**	**13**
Other sciences	**427.7**	**427.0**	**365.1**	**347.8**	**304.1**	**297.8**	**−1**	**8**
TOTAL	**$6527.7**	**$6058.6**	**$5617.4**	**$5411.0**	**$4777.4**	**$4252.3**	**8%**	**9%**
ANNUAL CHANGE	**8%**	**8%**	**4%**	**13%**	**12%**	**12%**		

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

UNIVERSITY BASIC RESEARCH: Solid funding increases in all major fields

Federal obligations, $ millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Life sciences	**$2616.2**	**$2387.4**	**$2307.8**	**$2306.8**	**$1979.6**	**$1701.7**	**10%**	**9%**
Physical sciences	**732.9**	**666.3**	**636.0**	**628.8**	**581.9**	**502.2**	**10**	**8**
Chemistry	270.9	244.5	232.5	234.9	212.1	181.9	11	8
Physics	368.0	336.0	325.9	317.0	293.9	264.7	10	7
Engineering	**496.6**	**430.3**	**429.2**	**366.6**	**340.3**	**295.5**	**15**	**11**
Chemical	41.0	35.4	33.3	27.6	29.6	18.9	16	17
Metallurgy and materials	134.8	115.0	120.4	95.8	79.9	76.8	17	12
Environmental sciences	**405.5**	**356.4**	**335.5**	**330.7**	**288.9**	**284.3**	**14**	**7**
Mathematics and computer sciences	**225.7**	**204.8**	**188.7**	**172.1**	**152.6**	**146.8**	**10**	**9**
Other sciences	**220.0**	**213.4**	**191.0**	**169.0**	**147.4**	**147.2**	**3**	**8**
TOTAL	**$4696.9**	**$4258.5**	**$4088.4**	**$3974.0**	**$3490.7**	**$3077.7**	**10%**	**9%**
ANNUAL CHANGE	**10%**	**4%**	**3%**	**14%**	**13%**	**14%**		

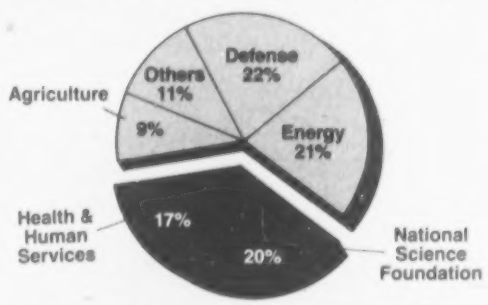
Note: Fiscal years. a Estimated. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR CHEMICAL RESEARCH: No net gain despite 11% rise in NSF support

$ Millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Defense	**$151.9**	**$151.7**	**$163.4**	**$156.4**	**$139.8**	**$121.8**	**0%**	**5%**
Army	68.6	71.4	81.4	78.2	66.3	59.3	−4	3
Air Force	44.9	39.5	42.0	39.5	36.7	31.2	13	8
Navy	38.4	40.5	39.1	38.3	36.6	31.1	−5	4
Defense agencies	0	0.2	0.9	0.4	0.3	0.3	—	—
Energy	**144.0**	**156.5**	**145.9**	**143.0**	**140.4**	**117.6**	**−8**	**4**
National Science Foundation	**137.2**	**124.0**	**112.6**	**115.6**	**109.9**	**92.4**	**11**	**8**
Health & Human Services	**116.4**	**117.3**	**104.2**	**99.1**	**86.3**	**74.2**	**−1**	**9**
National Institutes of Health	110.0	109.6	99.5	95.1	84.1	72.2	0	9
Alcohol, Drug Abuse & Mental Health	6.4	7.8	4.7	4.0	2.3	2.0	−18	26
Agriculture	**63.6**	**62.8**	**58.6**	**58.0**	**69.0**	**63.8**	**1**	**0**
Agricultural Research Service	45.5	42.3	40.0	36.1	51.6	49.5	8	−2
Cooperative State Research Service	11.3	13.6	12.4	16.1	13.5	10.8	−16	1
Forest Service	6.8	7.0	6.2	5.7	3.9	3.6	−3	14
Environmental Protection Agency	**20.1**	**22.9**	**20.1**	**17.5**	**15.9**	**14.8**	**−12**	**6**
Interior	**19.9**	**20.7**	**20.3**	**19.4**	**19.2**	**6.2**	**−4**	**26**
Geological Survey[b]	19.7	20.5	20.2	19.4	18.4	5.6	−4	29
Commerce	**17.4**	**17.7**	**19.1**	**17.7**	**15.3**	**14.0**	**−2**	**4**
National Bureau of Standards	16.1	15.5	16.4	15.4	14.1	12.7	3	5
National Oceanic & Atmospheric Administration	1.3	2.1	2.4	1.4	1.3	1.2	−39	2
National Aeronautics & Space Administration	**14.3**	**14.5**	**11.8**	**16.3**	**7.3**	**9.4**	**−1**	**9**
Others	**7.1**	**7.8**	**6.3**	**1.5**	**3.3**	**6.1**	**−8**	**3**
TOTAL	**$692.0**	**$696.0**	**$662.4**	**$644.5**	**$606.4**	**$520.3**	**−1%**	**6%**
ANNUAL CHANGE	**−1%**	**5%**	**3%**	**6%**	**17%**	**8%**		

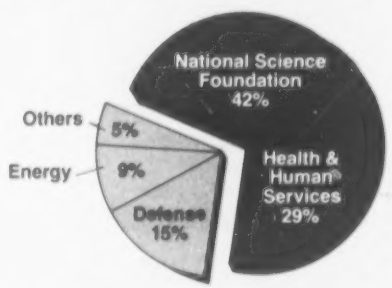
Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. **Source:** National Science Foundation

NSF and HHS provide about one third of federal funds for chemical research . . .



Estimated fiscal 1988 federal chemistry research obligations = $692 million

. . . but more than two thirds of the funds for chemical research at universities



Estimated fiscal 1988 federal chemistry university research obligation = $308 million

Source: National Science Foundation

UNIVERSITY RESEARCH IN CHEMISTRY: NSF and NIH support 70% of total

Federal obligations, $ millions	1988[a]	1987[a]	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
National Science Foundation	**$127.5**	**$115.3**	**$103.5**	**$108.1**	**$100.7**	**$ 84.7**	**11%**	**8%**
Health & Human Services	**86.6**	**81.0**	**75.0**	**75.2**	**63.2**	**51.9**	**9**	**11**
National Institutes of Health	87.7	80.0	74.4	74.7	62.8	51.4	10	11
Alcohol, Drug Abuse & Mental Health	0.9	1.1	0.6	0.6	0.4	0.5	−12	15
Defense	**46.5**	**41.9**	**43.2**	**40.4**	**34.7**	**31.4**	**11**	**8**
Energy	**29.2**	**26.7**	**27.6**	**26.0**	**26.3**	**18.8**	**10**	**9**
Agriculture	**11.2**	**13.3**	**12.2**	**15.5**	**13.5**	**14.5**	**−16**	**− 5**
National Aeronautics & Space Administration	**5.2**	**4.7**	**4.2**	**4.1**	**4.1**	**4.6**	**10**	**2**
TOTAL	**$308.3**	**$282.9**	**$265.7**	**$269.4**	**$242.3**	**$205.7**	**9%**	**8%**
ANNUAL CHANGE	**9%**	**6%**	**−1%**	**11%**	**18%**	**na**		

Note: Fiscal years. Data from these six agencies represent approximately 96% of federal obligations for 1988. a Estimated. na = not available. **Source:** National Science Foundation

BASIC RESEARCH IN PHYSICAL SCIENCES: Boosts by Energy, NSF offset drop by NASA

Federal obligations, $ millions	1988[a]		1987[a]		1986		1985		1984	
	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Energy	$ 885.5	$119.4	$ 824.2	$121.0	$ 737.1	$110.6	$ 736.1	$102.3	$ 688.4	$108.4
National Aeronautics & Space Administration	538.4	7.1	580.4	8.4	471.9	5.5	377.9	10.2	338.7	5.4
National Science Foundation	402.0	133.2	362.3	120.5	343.7	109.5	347.9	112.7	330.2	106.8
Defense	177.9	70.8	174.0	69.7	192.0	73.3	185.5	70.1	212.2	60.0
Navy	74.7	24.6	74.2	27.4	77.6	26.5	73.9	26.7	100.4	20.7
Air Force	59.9	25.7	54.6	23.5	57.6	24.7	54.1	22.8	48.3	20.3
Army	43.3	20.5	43.4	18.6	50.6	21.2	54.3	20.6	59.8	19.1
Defense agencies	0	0	1.8	0.2	6.2	0.9	3.2	0	3.7	0
Health & Human Services	94.4	87.1	93.8	86.6	85.2	78.7	83.6	75.4	72.0	65.0
National Institutes of Health	91.3	84.2	89.7	82.7	82.7	76.3	81.5	73.3	70.8	63.8
Alcohol, Drug Abuse & Mental Health Administration	3.1	2.9	4.1	3.9	2.5	2.4	2.1	2.1	1.2	1.2
Agriculture	37.1	35.2	35.9	34.1	33.6	31.9	35.6	33.6	45.4	43.5
Agricultural Research Service	28.0	26.9	26.0	25.0	24.7	23.6	25.2	23.9	37.4	36.0
Forest Service	4.6	3.9	4.8	4.0	4.2	3.5	4.0	3.3	2.6	2.1
Cooperative State Research Service	4.4	4.4	5.1	5.1	4.8	4.8	6.4	6.4	5.4	5.4
Commerce	19.4	7.3	19.7	7.7	21.6	8.3	19.7	7.2	16.3	4.8
National Bureau of Standards	19.4	7.3	19.7	7.7	21.3	7.9	18.9	6.4	16.3	4.8
Interior	7.6	6.0	7.7	6.1	7.9	6.3	7.6	6.0	7.1	5.6
Geological Survey[b]	7.6	6.0	7.7	6.1	7.9	6.3	7.6	6.0	7.1	5.6
Environmental Protection Agency	5.9	4.8	6.5	5.2	4.7	4.3	3.5	3.0	3.0	3.0
Others	19.4	4.3	19.3	4.9	16.6	4.9	16.6	0.3	14.7	0.9
TOTAL	$2187.6	$475.4	$2122.8	$464.3	$1914.4	$433.4	$1814.0	$420.8	$1728.0	$403.4
ANNUAL CHANGE	3%	2%	11%	7%	6%	3%	5%	4%	9%	11%

Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. **Source:** National Science Foundation

ENGINEERING RESEARCH: Support for all engineering unchanged in 1988 although that for chemical

Federal obligations, $ millions	1988[a]			1987[a]			1986	
	All engineering	Chemical engineering	Metallurgy & materials	All engineering	Chemical engineering	Metallurgy & materials	All engineering	Chemical engineering
Defense	$1568.0	$ 55.2	$262.5	$1498.8	$ 47.8	$238.6	$1505.6	$ 50.3
Air Force	485.4	7.3	20.4	415.2	2.9	29.0	444.7	1.9
Army	391.8	23.6	25.6	377.6	21.0	24.6	373.6	24.0
Navy	399.6	24.4	114.6	364.5	23.9	105.1	397.8	24.4
Defense agencies	291.1	0	102.0	341.4	0	79.8	289.5	0
National Aeronautics & Space Administration	1343.5	1.2	22.2	1301.8	1.1	22.0	1066.9	1.0
Energy	337.2	59.4	82.6	485.9	127.0	89.8	494.2	121.6
National Science Foundation	276.0	47.3	51.3	224.1	37.7	46.0	199.1	33.4
Interior	77.5	4.6	29.0	101.1	4.8	41.0	93.2	4.7
Transportation	55.0	0.2	0.7	53.9	0.5	1.9	52.8	1.9
Environmental Protection Agency	45.4	23.7	0.5	42.7	20.8	0.5	48.6	23.9
Commerce	45.1	2.8	11.0	44.4	2.8	10.0	41.7	2.6
Agriculture	30.6	6.7	0	34.9	6.5	0	31.1	6.0
Others	198.1	0.1	0.1	191.0	0	0.5	205.9	0.4
TOTAL	$3976.3	$201.1	$459.9	$3978.6	$246.8	$450.1	$3738.9	$245.8
ANNUAL CHANGE	0%	−19%	2%	6%	1%	1%	3%	−3%

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

APPLIED RESEARCH IN PHYSICAL SCIENCES: Energy lowers chemistry funding by 31%

Federal obligations, $ millions	1988[a]		1987[a]		1986		1985		1984	
	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Energy	$ 516.7	$ 24.6	$ 534.1	$ 35.5	$ 529.4	$ 35.3	$ 606.1	$ 40.6	$ 603.5	$ 32.0
Defense	388.4	81.1	376.2	82.0	400.0	90.0	412.0	86.3	477.2	79.8
Army	88.3	48.1	101.8	52.9	109.0	60.1	124.2	57.5	77.4	47.2
Air Force	66.0	19.1	55.5	16.1	59.7	17.3	57.5	16.7	58.6	16.4
Navy	55.3	13.8	52.3	13.1	50.8	12.6	50.7	11.8	69.2	15.9
Defense agencies	178.9	0	166.6	0	180.5	0	179.6	0.4	272.1	0.3
National Aeronautics & Space Administration	96.5	7.2	82.6	6.0	82.7	6.3	76.3	6.1	25.6	1.9
Commerce	35.4	10.0	34.9	10.0	35.1	10.9	35.2	10.5	36.9	10.5
National Bureau of Standards	26.2	8.7	23.9	7.9	24.6	8.5	25.3	9.0	28.1	9.3
National Oceanic & Atmospheric Administration	9.1	1.3	11.1	2.1	10.5	2.4	9.9	1.4	8.9	1.3
Health & Human Services	33.1	29.2	34.7	30.7	29.0	25.6	27.3	23.6	24.7	21.3
National Institutes of Health	29.4	25.8	30.6	26.8	26.5	23.2	25.4	21.8	23.6	20.3
Alcohol, Drug Abuse & Mental Health Administration	3.6	3.4	4.1	3.9	2.5	2.3	1.9	1.9	1.1	1.1
Agriculture	30.5	28.4	30.8	28.7	28.6	26.7	26.4	24.4	27.3	25.5
Agricultural Research Service	19.4	18.6	18.1	17.3	17.1	16.4	13.1	12.2	16.9	15.6
Cooperative State Research Service	6.9	6.9	8.5	8.5	7.6	7.6	9.7	9.7	8.1	8.1
Forest Service	4.1	2.9	4.2	3.0	3.9	2.7	3.5	2.4	2.4	1.8
Environmental Protection Agency	17.3	15.4	18.8	17.7	18.5	15.8	15.7	14.5	13.8	12.9
Interior	16.1	13.9	16.9	14.6	16.2	14.0	15.5	13.3	15.7	13.6
Geological Survey[b]	15.8	13.7	16.7	14.4	16.2	13.9	15.5	13.3	14.9	12.8
National Science Foundation	14.6	4.1	12.9	3.5	12.2	3.1	11.8	2.9	10.9	3.1
Others	8.0	2.8	5.1	2.9	2.9	1.5	3.8	1.4	5.4	2.4
TOTAL	$1156.4	$216.7	$1147.1	$231.8	$1154.6	$229.0	$1230.1	$223.6	$1241.0	$203.0
ANNUAL CHANGE	1%	−7%	−1%	1%	−6%	2%	−1%	10%	−5%	28%

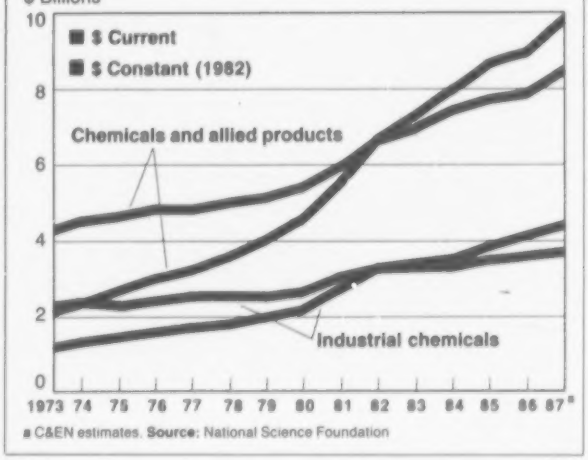
Note: Fiscal years. a Estimated. b Includes the Office of Water Research & Technology. **Source:** National Science Foundation

engineering falls off significantly as a result of drop in Energy funds

1986	1985			1984			1983		
Metallurgy & materials	All engineering	Chemical engineering	Metallurgy & materials	All engineering	Chemical engineering	Metallurgy & materials	All engineering	Chemical engineering	Metallurgy & materials
$253.7	$1502.0	$ 53.3	$260.9	$1488.4	$ 38.4	$180.3	$1573.9	$44.9	$179.3
33.4	423.9	1.7	28.6	439.5	3.5	30.3	419.3	3.1	36.2
26.8	344.3	26.7	42.2	324.8	23.5	35.5	318.9	29.3	28.4
117.4	421.2	24.8	121.1	398.4	11.3	53.9	395.5	11.9	50.0
76.2	312.6	0.1	69.0	325.7	0.2	60.6	440.2	0.6	62.8
16.2	931.6	0.6	15.8	967.8	0.3	14.2	799.6	1.0	19.1
82.8	511.3	136.6	68.4	439.0	46.1	68.7	440.2	51.9	62.6
43.5	193.3	32.6	42.7	164.9	27.7	27.3	142.5	21.5	27.3
38.5	100.2	4.8	39.8	111.4	4.5	42.2	91.4	0.4	31.5
1.8	49.4	0.6	1.5	51.1	1.2	1.9	56.1	1.0	1.4
0.5	44.8	18.0	2.6	37.8	17.8	0	47.8	16.7	3.5
7.6	39.8	1.7	6.9	35.3	1.8	6.4	37.4	1.3	7.8
0	28.7	5.6	0	56.7	6.4	0	54.7	6.2	0
0.5	227.4	0.3	0.5	271.7	0.3	0.1	273.4	0.1	0
$445.0	$3628.5	$254.1	$439.1	$3624.1	$144.5	$341.1	$3517.0	$145.0	$332.5
1%	0%	76%	29%	3%	0%	3%	4%	52%	8%

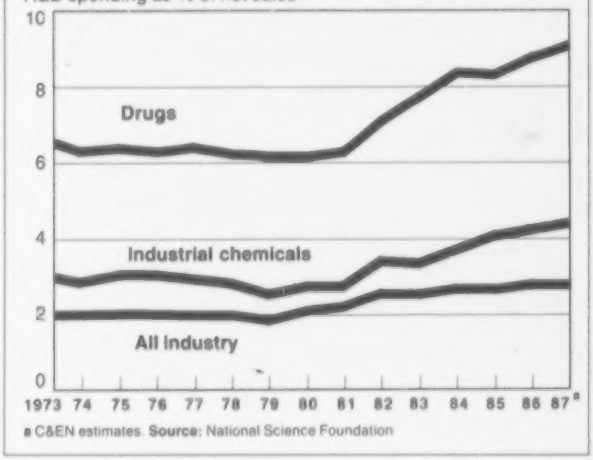
R&D rebounds after slow growth in 1986

Chemical industry R&D outlays keep growing, even after inflation adjustment



a C&EN estimates. **Source:** National Science Foundation

Chemical companies are spending an increasing part of revenues on R&D



a C&EN estimates. **Source:** National Science Foundation

TOTAL FUNDS FOR INDUSTRIAL R&D: Increases run slightly behind 10-year averages

$ Millions	1987a	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	Annual change 1986–87	Annual change 1977–87
Chemicals and allied products	**9,950**	**9,021**	**8,690**	**8,028**	**7,293**	**6,659**	**5,625**	**4,636**	**4,038**	**3,580**	**3,202**	10%	12%
Industrial chemicals	4,400	4,059	3,899	3,512	3,411	3,301	2,802	2,197	1,962	1,798	1,668	8	10
Drugs and other chemicals	5,550	4,962	4,791	4,516	3,882	3,358	2,823	2,439	2,076	1,782	1,534	12	14
Other industries	**76,150**	**71,608**	**70,086**	**63,442**	**56,110**	**51,337**	**46,185**	**39,869**	**34,188**	**29,724**	**26,623**	6	11
TOTAL	**86,100**	**80,629**	**78,776**	**71,470**	**63,403**	**57,996**	**51,810**	**44,505**	**38,226**	**33,304**	**29,825**	7%	11%

a C&EN estimates. **Source:** National Science Foundation

COMPANY FUNDS FOR INDUSTRIAL R&D: A sixth of total spent by chemical industry

$ Millions	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1985–86	Annual change 1976–86
Chemicals and allied products	**8,773**	**8,391**	**7,797**	**6,845**	**6,226**	**5,205**	**4,264**	**3,692**	**3,250**	**2,907**	**2,751**	5%	12%
Industrial chemicals	3,812	3,618	3,289	2,970	2,879	2,393	1,856	1,617	1,473	1,387	1,275	5	12
Drugs	3,785	3,580	3,381	2,937	2,490	2,064	1,756	2,075	1,777	1,520	1,476	6 —	— 13
Other chemicals	1,176	1,193	1,126	938	856	747	653					−1	—
Other industries	**44,074**	**43,556**	**40,511**	**36,016**	**33,286**	**30,223**	**26,212**	**22,016**	**18,865**	**16,433**	**14,685**	1	12
TOTAL	**52,847**	**51,947**	**48,308**	**42,861**	**39,512**	**35,428**	**30,476**	**25,708**	**22,115**	**19,340**	**17,436**	2%	12%

Source: National Science Foundation

FEDERAL FUNDS FOR INDUSTRIAL R&D: Only a small share goes to chemical industry

$ Millions	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1985–86	Annual change 1976–86
Chemicals and allied products	$ 248	$ 299	$ 232[a]	$ 448	$ 434	$ 421	$ 372	$ 346	$ 330	$ 295	$ 266	−17%	−1%
Industrial chemicals	247	282	223	440	423	409	341	345	325	281	249	−12	0
Drugs and other chemicals	1	17	9	8	11	12	31	1	5	14	17	−94	−25
Other industries	27,534	26,531	22,930	20,094	18,049	15,961	13,657	12,172	10,859	10,190	9295	4	11
TOTAL	$27,782	$26,830	$23,162	$20,542	$18,483	$16,382	$14,029	$12,518	$11,189	$10,485	$9561	4%	11%

a The decline in 1984 from 1983 results from the administration of federally funded Oak Ridge National Laboratory being changed from a chemical company to a company in the aircraft and missile industry. **Source:** National Science Foundation

R&D BY U.S. COMPANIES ABROAD: Spending was up sharply in 1986

$ Millions	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1985–86	Annual change 1976–86
Chemicals and allied products	$1075	$ 847	$ 793	$ 732	$ 684	$ 715	$ 603	$ 500	$ 395	$ 332	$ 312	27%	13%
Industrial and other chemicals	523	410	363	354	313	287	245	199	151	133	108	28	17
Drugs	552	437	430	378	371	428	357	301	244	199	204	26	10
Other industries	3600	2818	2786	2544	2413	2679	2562	2254	1814	1545	1347	28	10
TOTAL	$4675	$3665	$3579	$3276	$3097	$3393	$3165	$2754	$2209	$1877	$1659	28%	11%

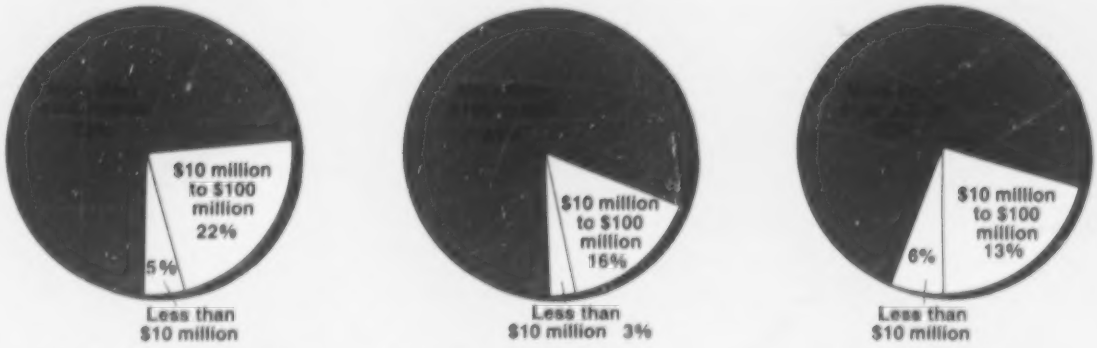
Source: National Science Foundation

CHEMICAL R&D SPENDING: Most chemical producers hiked budgets last year

$ Millions	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1987 R&D spending as % of sales
Du Pont	$1223	$1156	$1144	$1097	$ 966	$ 879	$ 718	$ 591	$ 509	$ 461	$ 367	4.0%
Dow Chemical	670	605	547	507	492	460	404	314	269	232	203	5.0
Monsanto	615	596	470	370	290	264	233	208	161	136	132	6.1
American Cyanamid	314	278	251	232	208	185	166	148	130	108	96	7.5
PPG Industries	227	204	176	150	127	127	119	103	83	70	61	4.4
Union Carbide[a]	159	148	275	265	245	240	207	166	161	156	156	2.3
Rohm & Haas	142	133	124	109	100	92	77	67	54	49	45	6.4
W. R. Grace	107	94	92	81	73	64	57	45	42	37	32	2.4
Hercules	74	71	76	72	74	74	65	57	50	43	40	2.7
Lubrizol	62	51	44	33	37	36	33	28	23	21	19	6.1
Olin	62	56	53	52	49	45	38	31	26	25	25	3.2
Air Products	57	61	51	44	40	37	32	30	24	23	24	2.7
Ethyl	50	47	47	40	39	39	37	34	29	25	28	2.9
International Flavors	45	39	34	32	32	31	30	29	27	24	20	6.0
Pennwalt	45	45	39	36	33	31	27	24	22	23	21	3.9
Nalco Chemical	35	33	32	32	30	33	30	28	21	17	14	4.2
TOTAL	$3887	$3617	$3455	$3152	$2835	$2637	$2273	$1903	$1631	$1450	$1263	4.5%
ANNUAL CHANGE	7%	5%	10%	11%	8%	16%	19%	17%	12%	13%	9%		

Note: Prior years not restated to reflect company revisions. a Union Carbide divested a substantial part of its business in 1986; on a pro forma basis, R&D spending was $181 million in 1985 and $178 million in 1984. **Source:** Company data

Chemical firms with biggest research budgets do about three fourths of all chemical R&D


$10 million to $100 million 22%
5%
Less than $10 million
1986 chemicals and allied products R&D funds = $9.0 billion
$10 million to $100 million 16%
Less than $10 million 3%
1986 industrial chemicals R&D funds = $4.1 billion
$10 million to $100 million 13%
6%
Less than $10 million
1986 industry R&D funds = $80.6 billion

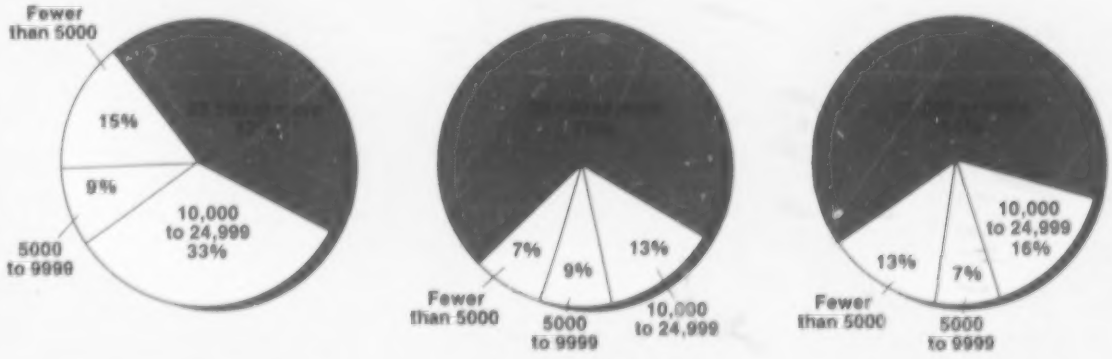
Note: Ranges indicate size of companies' 1986 R&D program. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS IN INDUSTRY: Not as many are working for chemical firms

Thousands	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1986–87	Annual change 1977–87
Chemicals and allied products	**66.1**	**70.0**	**67.0**	**67.1**	**66.0**	**61.6**	**54.7**	**51.4**	**50.0**	**48.3**	**46.4**	**44.4**	**−6%**	**4%**
Industrial chemicals	27.1	27.1	25.0	26.7	27.2	25.9	21.6	20.9	21.4	21.3	20.6	20.1	0	3
Drugs	29.0	31.6	30.7	30.1	28.2	25.6	23.3	21.6	20.8	19.5	17.8	16.6	−8	5
Other chemicals	10.1	11.3	11.3	10.3	10.6	10.1	9.8	8.9	7.8	7.5	8.0	7.8	−11	2
Other industries	**518.4**	**513.6**	**493.2**	**477.4**	**456.1**	**448.2**	**433.1**	**399.2**	**373.9**	**356.1**	**336.4**	**320.0**	**1**	**4**
TOTAL	**584.5**	**583.6**	**560.2**	**544.5**	**522.1**	**509.8**	**487.8**	**450.6**	**423.9**	**404.4**	**382.8**	**364.4**	**0%**	**4%**

Note: Data as of January of each year for full-time-equivalent personnel. **Source:** National Science Foundation

Companies employing more than 25,000 perform the most R&D

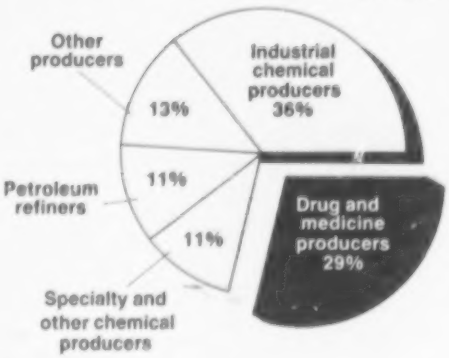


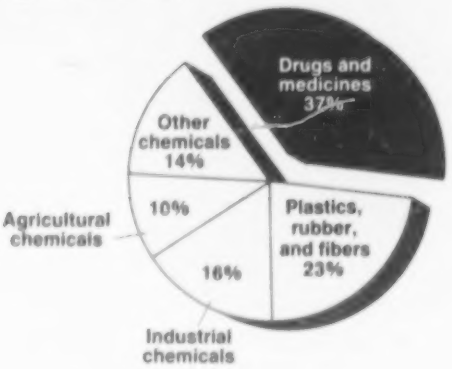
Note: Ranges indicate companies' number of employees in 1986. [a] Excludes federal funding. **Source:** National Science Foundation

Drug companies trail industrial chemical producers as performers of chemical R&D . . .

. . . but research on drugs accounts for largest share of R&D funds

1985 chemical R&D spending[a] = $8.0 billion





a Excludes basic research. **Source:** National Science Foundation

BASIC RESEARCH IN INDUSTRY: Chemical companies account for a fourth

$ Millions	1985	1984	1983	1981	1979	1977	1976	1975	Annual change 1984-85	Annual change 1975-85
Chemicals and allied products	**$ 708**	**$ 672**	**$ 572**	**$ 539**	**$ 366**	**$337**	**$332**	**$298**	**5%**	**9%**
Industrial chemicals	363	338	348	335	190	183	168	155	7	9
Drugs	293	293	195	180	150	130	128	113	0	10
Other chemicals	52	41	29	24	26	25	36	31	27	5
Other industries	**1939**	**1803**	**1580**	**1075**	**792**	**574**	**505**	**432**	**8**	**16**
TOTAL	**$2647**	**$2475**	**$2152**	**$1614**	**$1158**	**$911**	**$837**	**$730**	**7%**	**14%**

Note: No data for 1978, 1980, and 1982. **Source:** National Science Foundation

APPLIED RESEARCH IN INDUSTRY: Growing more slowly in chemical industry

$ Millions	1985	1984	1983	1981	1979	1977	1976	1975	Annual change 1984-85	Annual change 1975-85
Chemicals and allied products	**$ 3,230**	**$ 2,991**	**$ 2,671**	**$ 2,391**	**$1726**	**$1347**	**$1219**	**$1102**	**8%**	**11%**
Industrial chemicals	2,912	1,525	1,356	1,250	853	695	593	537	—	—
									8	12
Drugs		1,166	1,043	890	684	479	470	426	—	—
Other chemicals	318	300	272	251	189	173	156	138	6	9
Other industries	**13,804**	**12,037**	**10,834**	**8,308**	**5499**	**4289**	**3964**	**3477**	**15**	**15**
TOTAL	**$17,034**	**$15,028**	**$13,505**	**$10,699**	**$7225**	**$5936**	**$5183**	**$4578**	**13%**	**14%**

Note: No data for 1978, 1980, and 1982. **Sources:** National Science Foundation, C&EN estimates based on NSF data

DEVELOPMENT IN INDUSTRY: 8% of total outlay is spent by chemical firms

$ Millions	1985	1984	1983	1981	1979	1977	1976	1975	Annual change 1984-85	Annual change 1975-85
Chemicals and allied products	**$ 4,753**	**$ 4,365**	**$ 4,050**	**$ 2,665**	**$ 1,946**	**$ 1,518**	**$ 1,466**	**$ 1,330**	**9%**	**14%**
Industrial chemicals	3,916	3,566	1,707	1,191	920	790	763	700	—	—
									10	13
Drugs			1,613	1,000	682	508	493	444	—	—
Other chemicals	837	799	730	475	344	219	209	184	5	16
Other industries	**54,342**	**49,602**	**43,696**	**36,832**	**27,897**	**21,760**	**19,511**	**17,550**	**10**	**12**
TOTAL	**$59,095**	**$53,967**	**$47,746**	**$39,497**	**$29,843**	**$23,278**	**$20,977**	**$18,879**	**10%**	**12%**

Note: No data for 1978, 1980, and 1982. **Sources:** National Science Foundation, C&EN estimates based on NSF data

R&D SCIENTISTS AND ENGINEERS PER 1000 EMPLOYEES: High among drug companies

	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976
Chemicals and allied products	**61**	**53**	**54**	**54**	**51**	**44**	**42**	**42**	**43**	**42**	**40**
Industrial chemicals	53	42	44	45	44	37	36	36	38	38	36
Drugs	90	81	88	82	74	66	60	62	65	62	64
Other chemicals	40	39	37	36	36	33	30	27	27	29	28
All industry	**43**	**40**	**38**	**35**	**33**	**29**	**27**	**27**	**27**	**27**	**27**

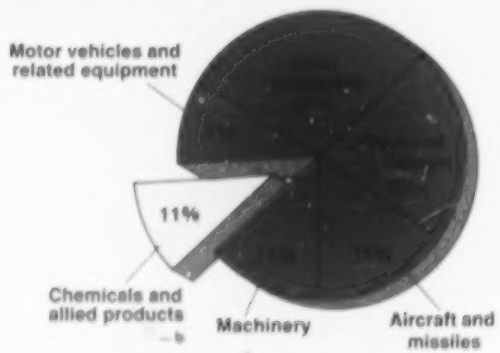
Source: National Science Foundation

COST PER INDUSTRIAL R&D SCIENTIST OR ENGINEER: 4% rise for chemicals in 1986

$ Thousands	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976
Chemicals and allied products	**$132.5**	**$126.9**	**$119.2**	**$109.6**	**$104.4**	**$ 96.6**	**$ 87.4**	**$79.6**	**$72.8**	**$67.6**	**$66.5**
Industrial chemicals	149.6	149.7	a	126.6	124.3	118.0	103.4	92.8	84.2	79.6	74.7
Drugs	125.0	114.9	a	100.7	a	a	79.2	71.4	64.8	59.9	63.4
Other chemicals	110.2	107.1	a	a	a	a	66.5	66.5	61.6	53.8	50.8
All industry	**$138.1**	**$137.8**	**$129.8**	**$118.9**	**$112.4**	**$103.9**	**$ 94.9**	**$87.4**	**$80.4**	**$75.8**	**$72.2**

a Not separately available but included in chemicals and allied products. **Source:** National Science Foundation

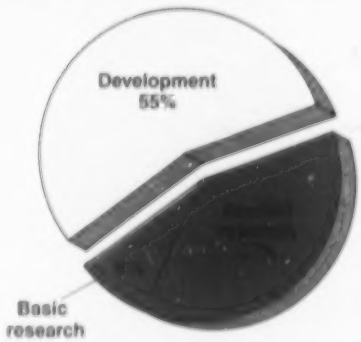
Chemical companies employ 11% of R&D scientists and engineers in industry



1987 total industrial R&D scientists and engineers[a] = 584,500

a Full-time equivalent as of January 1987. **Source:** National Science Foundation

Development claims just over half of chemical industry's R&D spending



1985 total chemical R&D expenditures = $8.69 billion

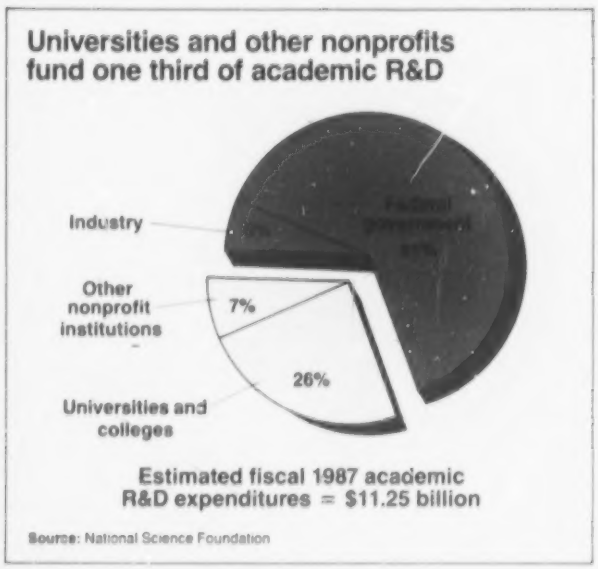
Source: National Science Foundation

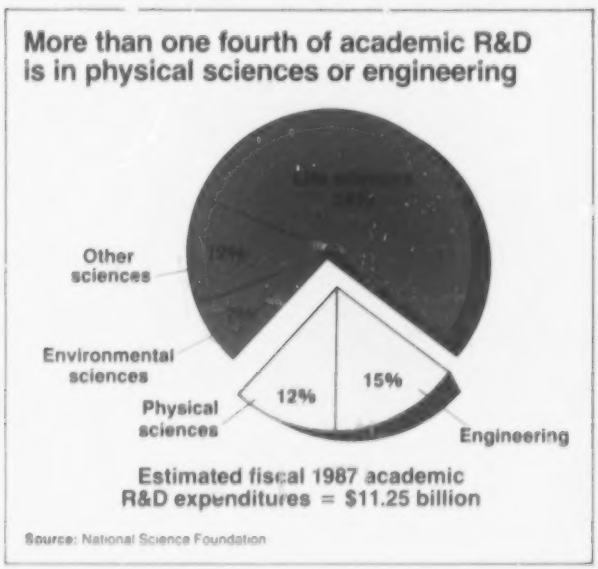
CHEMISTS IN INDUSTRY: Best paid work for chemical producers, drug, and petroleum firms

	% of industrial chemists				Mean salary ($ thousands)[a]		
Industry	All chemists	B.S.	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Pharmaceuticals[b]	16%	15%	19%	16%	$37.9	$44.9	$62.6
Specialty chemicals	15	15	13	15	39.5	45.9	58.8
Basic chemicals	7	4	5	9	43.7	48.9	62.8
Plastics	5	4	6	6	40.7	45.0	62.1
Petroleum and natural gas	4	4	3	4	42.2	50.8	64.5
Coatings	4	6	5	2	38.2	46.0	51.5
Electronics	4	3	3	4	41.0	47.6	62.5
Food	4	4	4	3	40.3	47.4	59.7
Agricultural chemicals	4	3	3	5	39.9	44.1	61.8
Metals and minerals	2	2	2	1	36.0	39.4	53.2
Rubber	2	2	1	1	40.8	40.9	56.6
Soaps and detergents	1	1	1	2	40.3	44.7	61.1
Paper	1	1	2	1	38.0	41.3	56.7
Other manufacturing	18	19	18	18	40.0	49.1	58.9
Nonmanufacturing	12	15	13	9	38.2	46.5	57.1

a As of March 1, 1988; to facilitate comparison, mean salaries are adjusted for differences in average length of experience for each group. b Includes personal care products. **Source:** American Chemical Society survey

University R&D growth rate falls to 5%


Universities and other nonprofits fund one third of academic R&D
Industry
Other nonprofit institutions
7%
26%
Universities and colleges
Estimated fiscal 1987 academic R&D expenditures = $11.25 billion
Source: National Science Foundation



CHARACTER OF UNIVERSITY R&D SPENDING: Two thirds of total goes to basic research

$ Millions	1987[a]	1986	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	Annual change 1986–87	Annual change 1977–87
Basic research	$ 7,610	$ 7,244	$6387	$5638	$5265	$4851	$4571	$4027	$3612	$3176	$2800	5%	11%
Applied research	3,020	2,879[a]	2584[a]	2395[a]	2097[a]	2001[a]	1862[a]	1691	1465	1213	1067	5	11
Development	620	596[a]	554[a]	476[a]	436[a]	414[a]	376[a]	343	284	236	200	4	12
TOTAL	$11,250	$10,718	$9524	$8508	$7798	$7266	$6810	$6061	$5361	$4625	$4067	5%	11%
ANNUAL CHANGE	5%	13%	12%	9%	7%	7%	12%	13%	16%	14%	9%		

Note: Data for institutional fiscal years. a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. **Source:** National Science Foundation

SOURCE OF UNIVERSITY R&D FUNDS: More than 60% comes from federal government

$ Millions	1987[a]	1986	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	Annual change 1986–87	Annual change 1977–87
Federal government	$ 6,880	$ 6,633	$5998	$5386	$4953	$4747	$4557	$4097	$3595	$3059	$2726	4%	10%
Universities	2,680	2,677	2286	2033	1880	1687	1517	1318	1198	1037	888	8	12
Industry	720	667	543	461	378	333	291	237	194	170	139	8	18
Other sources	770	740	698	629	587	499	445	408	374	359	314	4	9
TOTAL	$11,250	$10,718	$9524	$8508	$7798	$7266	$6810	$6061	$5361	$4625	$4067	5%	11%

Note: Data for institutional fiscal years. a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. **Source:** National Science Foundation

FIELDS OF UNIVERSITY R&D SPENDING: **Physical sciences get 12% of total**

$ Millions	1987[a]	1986	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	Annual change 1986–87	Annual change 1977–87
All sciences	**$ 9,550**	**$ 9,109**	**$8138**	**$7301**	**$6687**	**$6241**	**$5849**	**$5196**	**$4593**	**$4024**	**$3569**	**5%**	**10%**
Life	6,020	5,746	5155	4617	4233	3970	3671	3216	2833	2538	2259	5	10
Physical	1,325	1,261	1334	992	897	823	765	677	602	469	424	5	12
Physics	655	622	550	489	414	366	357	322	292	235	202	5	13
Chemistry	485	460	412	368	335	308	284	244	206	183	159	5	12
Environmental	805	774	705	650	619	558	549	509	453	379	319	4	10
Psychology and social	680	640	552	519	493	491	499	453	396	367	353	6	7
Computer	330	315	279	222	175	149	133	114	98	67	56	5	19
Mathematical	160	152	130	124	108	99	89	79	79	59	52	5	12
Others	230	220	182	176	162	152	114	146	134	117	106	5	8
Engineering	**1,700**	**1,609**	**1387**	**1207**	**1111**	**1026**	**961**	**885**	**768**	**601**	**499**	**6**	**13**
Chemical	130	125	109	96	91	84	82	68	na	na	na	4	—
TOTAL	**$11,250**	**$10,718**	**$9524**	**$8508**	**$7798**	**$7266**	**$6810**	**$6061**	**$5361**	**$4625**	**$4067**	**5%**	**11%**
ANNUAL CHANGE	**5%**	**13%**	**12%**	**9%**	**7%**	**7%**	**12%**	**13%**	**16%**	**14%**	**9%**		

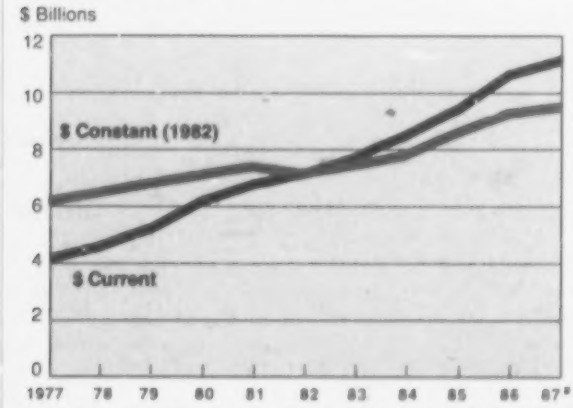
Note: Data for institutional fiscal years. a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. na = not available. **Source:** National Science Foundation

FEDERALLY FINANCED R&D SPENDING AT UNIVERSITIES: **Computer field growing strongly**

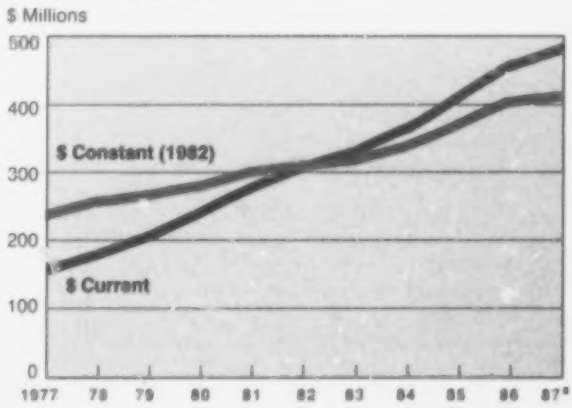
$ Millions	1987[a]	1986	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	Annual change 1986–87	Annual change 1977–87
All sciences	**$5870**	**$5665**	**$5141**	**$4608**	**$4216**	**$4049**	**$3895**	**$3502**	**$3069**	**$2651**	**$2389**	**4%**	**9%**
Life	3550	3440	3141	2796	2563	2493	2363	2095	1819	1626	1474	3	9
Physical	1020	976	883	779	697	649	618	555	491	392	339	5	12
Physics	530	510	455	388	340	306	309	280	253	199	172	4	12
Chemistry	350	338	307	278	248	230	216	189	157	138	122	4	11
Environmental	530	520	478	451	427	391	392	373	329	275	239	2	8
Psychology and social	290	285	262	243	238	251	279	263	227	204	202	2	4
Computer	250	227	193	162	128	107	93	77	69	41	38	10	21
Mathematical	120	112	96	91	76	72	68	61	60	44	41	7	11
Others	110	104	90	86	86	87	82	78	73	68	58	6	7
Engineering	**1010**	**968**	**856**	**778**	**737**	**698**	**662**	**595**	**526**	**408**	**337**	**4**	**12**
Chemical	70	68	58	54	52	50	55	46	na	na	na	6	—
TOTAL	**$6880**	**$6633**	**$5998**	**$5386**	**$4953**	**$4747**	**$4557**	**$4097**	**$3595**	**$3059**	**$2726**	**4%**	**10%**
ANNUAL CHANGE	**4%**	**11%**	**11%**	**9%**	**4%**	**4%**	**11%**	**14%**	**18%**	**12%**	**9%**		

Note: Data for institutional fiscal years. a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. **Source:** National Science Foundation

Growth slows for funding of all academic R&D . . .



. . . and for outlays for academic R&D in chemistry as well



Note: Data for institutional fiscal years. a Estimated. **Source:** National Science Foundation

TOP 10 UNIVERSITIES IN R&D SPENDING: Johns Hopkins spends 70% more than any other

$ Millions, fiscal 1986	Physical sciences	Chemistry[a]	Engineering	Environmental sciences	Life sciences	Math & computer sciences	Other sciences	Total
1 Johns Hopkins U	$ 67.7	$ 5.5	$ 138.4	$ 27.8	$ 116.1	$ 76.7	$ 14.1	$ 440.8
2 Massachusetts Inst. of Technology	77.6	13.6	107.9	11.9	34.3	13.2	13.0	257.7
3 U of Wisconsin, Madison	25.9	7.9	25.3	19.3	129.1	7.1	24.4	231.1
4 Cornell U	40.6	7.4	32.6	4.9	124.2	12.0	11.0	225.4
5 Stanford U	40.8	8.3	63.9	3.9	94.0	14.9	5.7	223.2
6 U of Minnesota	12.9	5.1	21.1	4.2	147.3	4.7	11.5	201.7
7 U of Michigan	13.2	2.9	30.5	10.4	88.1	4.5	41.1	187.9
8 U of Washington	11.2	3.0	17.7	19.6	111.2	5.6	21.2	186.6
9 U of California, Los Angeles	17.4	8.0	23.1	10.7	98.4	1.6	17.0	168.2
10 U of California, San Diego	22.9	6.5	2.9	63.5	63.9	4.6	3.2	161.1
TOTAL, FIRST 10 INSTITUTIONS	$ 330.2	$ 68.1	$ 463.4	$176.4	$1006.6	$144.7	$162.3	$ 2,283.6
TOTAL, ALL INSTITUTIONS	$1261.4	$460.1	$1609.1	$774.2	$5746.1	$467.6	$860.1	$10,718.4

Note: Data for institutional fiscal years. A number of institutions have developed or are in the process of developing new computer systems and methodologies that enable them to report more accurately the total cost of science and engineering research. Fiscal 1986 comparisons with data reported in earlier years may be inappropriate in some areas. a Included in physical sciences. **Source:** National Science Foundation

GRADUATE SCIENCE STUDENTS: Slight increases for all science and for chemistry

Thousands	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1985–86	Annual change 1976–86
All sciences	287.2	280.6	274.8	271.7	268.6	265.6	263.5	253.4	245.5	242.2	235.3	2%	2%
Physical sciences	30.6	29.3	28.4	27.7	26.5	25.8	25.4	24.9	24.7	24.8	24.8	4	2
Chemistry	17.6	17.2	16.6	16.5	15.8	15.2	15.1	14.9	14.8	14.6	14.4	3	2
Physics	12.1	11.3	11.0	10.5	10.0	9.9	9.6	9.3	9.2	9.5	9.6	7	2
Life sciences	95.9	93.3	92.4	91.2	90.7	90.9	90.7	87.5	85.9	83.3	77.2	3	2
Biochemistry	4.9	4.7	4.5	4.2	4.1	4.0	4.0	3.9	4.0	3.8	3.7	4	3
Environmental sciences	14.1	14.3	14.3	14.3	13.8	13.1	12.8	12.6	12.2	12.3	11.7	−2	2
Mathematical & computer sciences	41.0	39.1	35.4	33.2	30.3	27.1	25.0	22.7	21.5	21.1	21.7	5	7
Psychology and social sciences	105.6	104.7	104.2	105.4	107.3	108.7	109.7	105.8	101.2	100.6	99.8	1	1
Engineering	97.0	91.4	88.3	86.4	78.2	74.4	70.1	67.2	64.3	64.4	62.9	6	4
Chemical	6.9	7.0	7.2	7.4	6.9	6.3	5.9	5.4	5.2	5.1	5.1	−2	3
Metallurgical & materials	4.0	3.8	3.6	3.3	3.0	3.0	2.8	2.7	2.5	2.5	2.3	6	6
Petroleum	0.7	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	−9	6
TOTAL	384.2	372.0	363.1	358.1	346.8	340.0	333.7	320.6	309.8	306.6	298.2	3%	3%
ANNUAL CHANGE	3%	2%	1%	3%	2%	2%	4%	3%	1%	3%	1%		

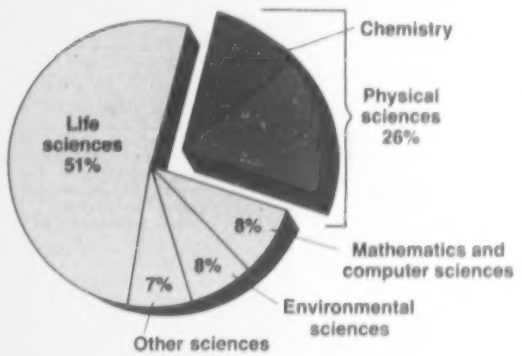
Note: Data for Ph.D.-granting institutions only. **Source:** National Science Foundation

TOP 10 UNIVERSITY R&D CENTERS: Top three get 64% of funds

$ Millions, fiscal 1986	Physical sciences	Engineering	Math & computer sciences	Environmental sciences	Life sciences	Psychology & social sciences	Other sciences	Total
1 Lawrence Livermore Lab	$ 255.1	$ 447.2	$114.3	$ 28.3	$ 23.7	$ 0	$0	$ 868.6
2 Jet Propulsion Lab	96.1	363.8	301.9	80.8	0	0	0	842.6
3 Los Alamos National Lab	378.7	264.4	74.6	17.9	20.2	14.8	7	777.5
4 Lincoln Lab	55.9	207.2[a]	30.9	0	0	0.3[a]	0	294.3
5 Argonne National Lab	83.8	126.7	3.5	31.5	14.0[a]	0	0	259.4
6 Brookhaven National Lab	146.8	32.7	0.8	6.1	20.5	3.0	0.2	212.2
7 Lawrence Berkeley Lab	103.6[a]	16.5[a]	5.5[a]	17.6[a]	30.0[a]	0	1.4[a]	174.6
8 Fermi National Accelerator Lab	148.6	0	0	0	0.5	0	0	149.1
9 Plasma Physics Lab	102.4	0	0	0	0	0	0	102.4
10 Stanford Linear Accelerator Center	80.3	0	0	0	0	0	0	80.3
All others	70.2	3.2	8.2	50.3	5.5	1.6	0	138.9
TOTAL, ALL FEDERALLY FUNDED R&D CENTERS	$1521.4	$1461.6	$539.7	$234.6	$114.4	$19.6	$8.6	$3900.1

Note: Data for university-administered, federally funded R&D centers. a Estimated. **Source:** National Science Foundation

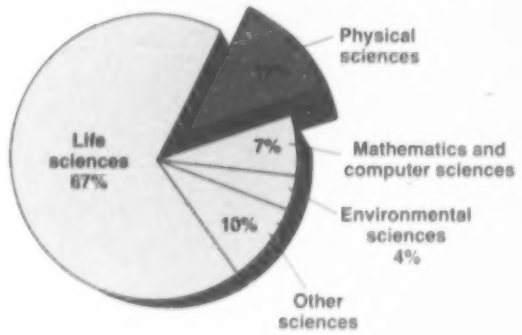
Chemistry departments get a tenth of university scientific equipment funds



1986 university spending for scientific research equipment = $626 million

Source: National Science Foundation

Physical sciences receive 12% of university capital spending on science



1986 university capital spending for all sciences = $1.26 billion

Source: National Science Foundation

UNIVERSITY SPENDING FOR RESEARCH EQUIPMENT: Nearly two thirds is federally funded

	1986		1985		1981		Annual change 1985–86		Annual change 1981–86	
$ Millions	Total	Federal funds	Total	Federal funds	Total	Federal funds	Total	Federal funds	Total	Federal funds
All sciences	**$626.0**	**$415.7**	**$535.4**	**$351.2**	**$345.0**	**$222.7**	**17%**	**18%**	**13%**	**13%**
Life sciences	**318.1**	**182.7**	**269.9**	**151.3**	**202.2**	**126.2**	**18**	**21**	**9**	**8**
Physical sciences	**164.1**	**133.4**	**141.9**	**113.3**	**76.1**	**58.5**	**16**	**18**	**17**	**18**
Physics	88.8	77.1	71.3	60.4	32.5	26.3	25	28	22	24
Chemistry	61.1	45.8	54.0	41.7	35.4	25.9	13	10	12	12
Mathematics & computer sciences	**51.5**	**42.6**	**44.4**	**37.4**	**12.8**	**6.5**	**16**	**14**	**32**	**45**
Environmental sciences	**50.7**	**35.4**	**47.0**	**32.1**	**31.5**	**19.2**	**8**	**10**	**10**	**13**
Other sciences	**41.6**	**21.5**	**32.2**	**17.0**	**22.3**	**12.3**	**29**	**26**	**13**	**12**
Engineering	138.9	81.0	119.2	75.6	69.0	42.4	16	7	15	14
Chemical	13.2	7.7	10.9	6.3	7.0	4.4	22	21	14	12
TOTAL	**$764.8**	**$496.7**	**$654.7**	**$426.9**	**$414.0**	**$265.0**	**17%**	**16%**	**13%**	**13%**

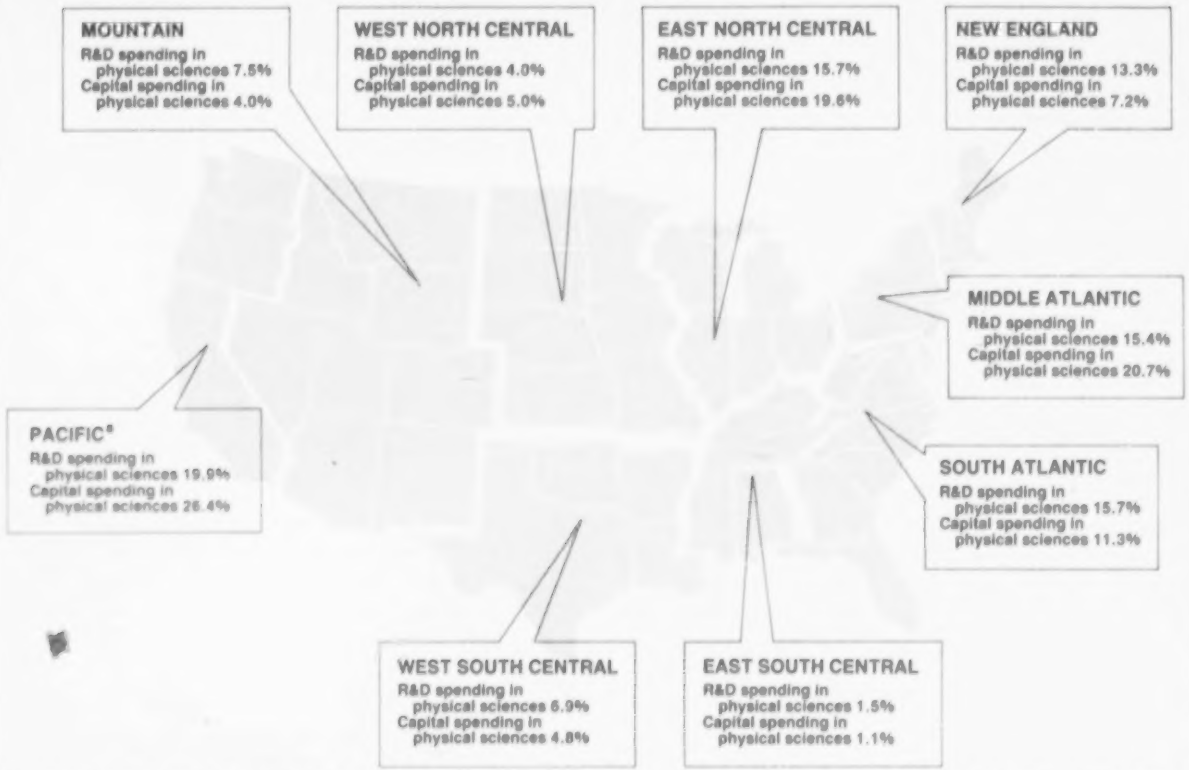
Note: Data for institutional fiscal years. **Source:** National Science Foundation

CAPITAL SPENDING AT UNIVERSITIES: Up strongly, especially for engineering

	1986							Annual change	
$ Millions	Total spending	% federal funds	1985	1984	1983	1982	1981	1985–86	1981–86
All sciences	**$1262.4**	**13%**	**$1125.3**	**$1072.4**	**$ 964.0**	**$824.7**	**$849.3**	**12%**	**8%**
Life sciences	839.9	11	751.6	741.4	678.8	590.4	597.6	12	7
Physical sciences	152.8	23	131.1	116.1	97.5	82.1	87.8	17	12
Mathematical & computer sciences	91.1	15	75.7	50.0	53.1	34.3	30.5	20	24
Psychology & social sciences	76.2	5	82.7	87.1	57.9	43.6	56.1	−8	6
Environmental sciences	47.1	13	54.1	36.8	41.1	42.4	35.0	−13	6
Other sciences	55.3	11	30.1	40.9	35.6	31.9	42.2	84	6
Engineering	**316.4**	**11**	**187.3**	**142.9**	**135.0**	**144.5**	**103.3**	**69**	**25**
TOTAL	**$1578.8**	**12%**	**$1312.7**	**$1215.2**	**$1098.9**	**$969.1**	**$952.7**	**20%**	**11%**
ANNUAL CHANGE	**20%**	**—**	**8%**	**11%**	**13%**	**2%**	**20%**		

Note: Data for institutional fiscal years. Includes expenditures for facilities and equipment for research, development, and instruction. **Source:** National Science Foundation

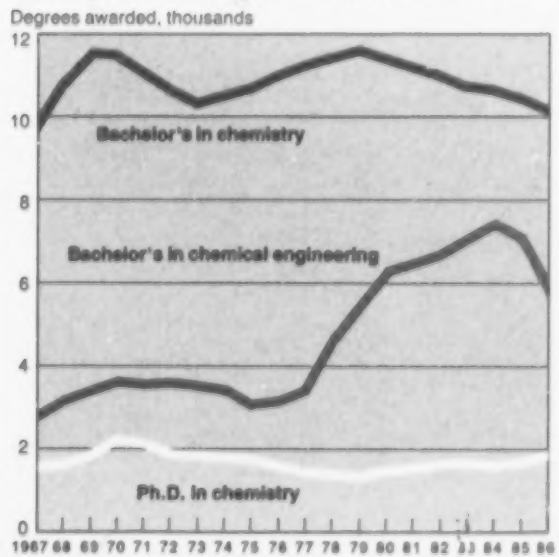
Capital spending is concentrated in the Pacific, Middle Atlantic, and East North Central regions, R&D spending on the East and West Coasts


MOUNTAIN
R&D spending in physical sciences 7.5%
Capital spending in physical sciences 4.0%
WEST NORTH CENTRAL
R&D spending in physical sciences 4.0%
Capital spending in physical sciences 5.0%
EAST NORTH CENTRAL
R&D spending in physical sciences 15.7%
Capital spending in physical sciences 19.6%
NEW ENGLAND
R&D spending in physical sciences 13.3%
Capital spending in physical sciences 7.2%
MIDDLE ATLANTIC
R&D spending in physical sciences 15.4%
Capital spending in physical sciences 20.7%
PACIFIC[a]
R&D spending in physical sciences 19.9%
Capital spending in physical sciences 26.4%
SOUTH ATLANTIC
R&D spending in physical sciences 15.7%
Capital spending in physical sciences 11.3%
WEST SOUTH CENTRAL
R&D spending in physical sciences 6.9%
Capital spending in physical sciences 4.8%
EAST SOUTH CENTRAL
R&D spending in physical sciences 1.5%
Capital spending in physical sciences 1.1%

Key to map: Using the Middle Atlantic states as an example, 15.4% of all R&D expenditures in the physical sciences and 20.7% of all capital expenditures in the physical sciences by all Ph.D.-granting universities and colleges are made in this area.

Note: Data based on $10.6 billion of R&D expenditures and $1.56 billion of capital expenditures in the physical sciences at all colleges and universities during the 1986 fiscal year. a Includes Alaska, Hawaii, and outlying areas. **Source:** National Science Foundation

Undergraduate degrees continue to slide



Note: Academic years. **Source:** National Center for Education Statistics

CHEMICAL DEGREES: 18% drop for chemical engineers at bachelor's level

Academic year	Degrees awarded in chemistry			Degrees awarded in chemical engineering		
	Bachelor's	Master's	Ph.D.	Bachelor's	Master's	Ph.D.
1967	9,872	1831	1744	2869	949	305
1968	10,847	2014	1757	3211	1156	367
1969	11,807	2070	1941	3557	1136	409
1970	11,617	2146	2208	3720	1045	438
1971	11,183	2284	2160	3615	1100	406
1972	10,721	2259	1971	3663	1154	394
1973	10,226	2230	1882	3636	1051	397
1974	10,525	2138	1828	3454	1045	400
1975	10,649	2006	1824	3142	990	346
1976	11,107	1796	1623	3203	1031	308
1977	11,322	1775	1571	3581	1086	291
1978	11,474	1892	1525	4615	1237	259
1979	11,643	1765	1518	5655	1149	304
1980	11,446	1733	1551	6383	1271	284
1981	11,347	1654	1622	6527	1267	300
1982	11,062	1751	1722	6740	1285	311
1983	10,746	1604	1746	7145	1304	319
1984	10,704	1667	1744	7475	1514	330
1985	10,482	1719	1789	7146	1544	418
1986	10,116	1754	1908	5877	1361	446

Source: National Center for Education Statistics

SCHOOLS SPENDING MOST ON CHEMICAL R&D: University of Texas makes big jump into top 10

Rank 1986	Rank 1985		1986 Total spending ($ thousands)	1986 % federal funds	1985	1984	1983	1982	1981	Annual change 1985–86	Annual change 1981–86
					($ thousands)						
1	1	Massachusetts Inst. of Technology	$ 13,593	95%	$ 13,221	$ 11,741	$ 8,914	$ 9,792	$ 8,222	3%	11%
2	6	California Inst. of Technology	9,176	83	7,605	6,446	6,994	6,136	6,901	21	6
3	2	U of California, Berkeley	9,114	91	10,804	7,850	7,945	6,283	6,553	−16	7
4	10	U of Illinois, Urbana	8,604	70	7,079	6,284	5,886	6,422	5,239	22	10
5	27	U of Texas, Austin	8,531	58	4,568	6,639	5,938	4,843	4,779	86	12
6	4	Stanford U	8,340	90	8,354	6,809	6,375	6,116	5,564	0	8
7	9	U of California, Los Angeles	7,954	94	7,243	7,219	5,496	5,187	4,420	10	12
8	8	U of Maryland, College Park	7,904	45	7,289	6,324	6,333[a]	4,718[a]	3,109	8	21
9	7	U of Wisconsin, Madison	7,892	68	7,350	6,076	5,310	4,567	4,122	7	14
10	5	Cornell U	7,376	80	7,962	6,710	5,717[a]	6,239[a]	4,618	−7	10
		Total, first 10 institutions	$ 88,484	79%	$ 81,495	$ 72,098	$ 64,908	$ 60,303	$ 53,527	9%	11%
11	3	Harvard U	7,202	94	6,557[a]	6,307[a]	6,898[a]	5,512[a]	6,123[a]	10	3
12	14	U of Chicago	7,084	91	6,287	5,735	4,798	4,396	4,139	13	11
13	13	U of Massachusetts, Amherst	6,888	63	6,291	6,137	5,162	4,364	3,230	9	16
14	19	Ohio State U	6,546	75	5,422	4,104	3,739	2,907	3,227	21	15
15	25	U of California, San Diego	6,535	91	4,642	4,355	3,910	3,894	4,430	41	8
16	11	Pennsylvania State U	6,438	80	6,509	5,124	4,729	3,564	3,413	−1	14
17	15	Purdue U	6,315	90	6,018	5,443	4,542	4,459	4,600	5	7
18	17	Indiana U	6,110	78	5,820	5,642	5,551	5,341	3,637	5	11
19	23	U of Pennsylvania	6,064	86	5,025	4,375	4,982	3,068	3,386	21	12
20	12	U of Colorado	5,830	84	6,360	4,134	3,302	3,492	4,047	−8	8
		Total, first 20 institutions	$153,496	81%	$140,426	$123,454	$112,521	$101,300	$ 93,759	9%	10%
21	16	Texas A&M U	5,752	54	5,896	4,610	4,963	4,521	4,069	−2	7
22	32	Princeton U	5,702	80	3,963	3,670	3,509	3,062	2,513	44	18
23	20	Columbia U, main division	5,555	91	5,188	4,662	4,281	4,700	3,564	7	9
24	29	Johns Hopkins U	5,506	89	4,612[a]	4,030	4,592[a]	4,721	4,066	23	6
25	18	U of Notre Dame	5,402	93	5,549	4,760	4,022	4,020	3,855	−3	7
26	24	U of Utah	5,354	89	4,840	3,830	3,638	3,364	3,076	11	12
27	34	Georgia Inst. of Technology	5,260	55	3,684	3,846	3,401	3,327	3,660	43	8
28	21	Yale U	5,125	88	5,096	4,134	3,341	2,875	2,781	1	13
29	31	U of Minnesota	5,110	79	4,167	4,067	4,047	4,297	4,260	23	4
30	26	U of Oregon, main campus	5,087	85	4,640	4,255	3,351	2,971	1,389	10	30
		Total, first 30 institutions	$207,349	81%	$188,061	$165,318	$151,666	$139,158	$126,992	10%	10%
31	30	U of Florida	5,050	47	4,380	4,024	2,347	2,248	2,302	15	17
32	28	U of Pittsburgh	4,974	81	4,580	3,965	3,267	2,714	2,039	9	20
33	22	Northwestern U	4,826	78	5,062	4,557	3,413	3,026	2,995	−5	10
34	33	U of South Carolina	4,298	76	3,729	3,423	2,721	2,483	1,087	15	32
35	50	Syracuse U	4,240	54	2,900	2,110	2,171	2,868	2,259	46	13
36	36	Lehigh U	4,237	41	3,456	3,361	3,664	2,584	1,680	23	20
37	40	Howard U	4,155[b]	93	3,269	3,672	2,336	982	1,406	27	24
38	58	Arizona State U	4,124	54	2,703	2,875	3,062	2,323	2,153	53	14
39	39	Florida State U	4,047	36	3,276	3,137	2,500	2,959	3,012	24	6
40	54	Colorado State U	3,867	88	2,775	2,688	2,478	2,479	2,385	39	10
		Total, first 40 institutions	$251,167	76%	$224,191	$199,130	$179,625	$163,824	$148,310	12%	11%
41	38	Virginia Polytechnic Inst. & State U	3,786	54	3,417	2,686	2,258	1,740	1,581	13	19
42	47	Iowa State U	3,709	36	2,988	2,239	1,903	1,462	1,272	24	24
43	92	Washington State U	3,623	67	1,356	692	558	583	na	167	—
44	43	U of Rochester	3,584	93	3,196	3,858	3,167	3,123	2,966	12	4
45	61	Rutgers U	3,507	61	2,368	2,301	1,830	1,390	1,385	48	20
46	45	U of California, Santa Barbara	3,506	68	3,060	2,172	1,902	1,698	1,834	15	14
47	44	U of California, Irvine	3,486	97	3,142	2,177	1,777	1,661	1,915	11	13
48	46	U of Virginia	3,436	80	3,046	2,516	2,069	1,778	1,781	13	14
49	49	Wayne State U	3,405	50	2,903	3,071	2,645	2,656	2,261	83	9
50	42	U of North Carolina, Chapel Hill	3,352	87	3,386	2,945	2,397	2,240	2,016	−1	11
		Total, first 50 institutions	$286,561	76%	$253,053	$223,787	$200,131	$182,155	$165,321[c]	14%	12%
		NATIONAL TOTAL	$460,084	73%	$411,615	$367,843	$334,663	$309,371	$285,520	11%	10%

Note: Data for institutional fiscal years. A number of institutions have developed or are in the process of developing new computer systems and methodologies that enable them to report more accurately the total cost of science and engineering research. Fiscal year 1986 comparisons with data reported in earlier years may be inappropriate in some areas. a Estimated. b Imputed. c. Total does not include spending at Washington State U. **Source:** National Science Foundation

SCHOOLS WITH MOST FEDERAL SUPPORT FOR CHEMICAL R&D: Top 10 get 20% of all support

Rank 1986	Rank 1985		1986	1985	1984	1983	1982	1981	Annual change 1985–86	Annual change 1981–86
			($ thousands)							
1	1	Massachusetts Inst. of Technology	$ 12,909	$ 12,424	$ 11,055	$ 8,374	$ 9,096	$ 7,572	4%	11%
2	2	U of California, Berkeley	8,258	9,892	7,263	7,467	5,691	6,008	−17	7
3	4	California Inst. of Technology	7,612	7,001	5,810	6,554	5,809	6,196[a]	9	4
4	3	Stanford U	7,524	7,097	6,120	5,968	5,893	5,337	6	7
5	5	U of California, Los Angeles	7,516	6,719	6,389	5,047	4,978	4,127	12	13
6	6	Harvard U	6,748	6,557	6,307	5,224	4,174	4,637	3	8
7	9	U of Chicago	6,472	5,715	5,116	3,998	3,716	3,719	13	12
8	12	U of Illinois, Urbana	5,999	5,371	5,005	4,668	4,763	3,847	12	9
9	7	Cornell U	5,934	6,293	5,775	4,766	5,437	4,062	−6	8
10	22	U of California, San Diego	5,918	4,053	3,780	3,490	3,506	3,933	46	9
		Total, first 10 institutions	$ 69,579	$ 65,450	$ 58,543	$ 52,898	$ 53,063	$ 49,438	6%	7%
11	11	Purdue U	5,708	5,418	4,452	3,966	3,946	3,715	5	9
12	13	U of Wisconsin, Madison	5,348	5,156	4,391	3,693	3,404	3,134	4	11
13	19	U of Pennsylvania	5,232	4,398	3,921	4,037	2,745	3,073	19	11
14	8	Pennsylvania State U	5,161	5,860	4,564	4,236	3,222	2,773	−12	13
15	17	Columbia U, main division	5,030	4,490	4,639	4,279	4,365	3,471	12	8
16	14	U of Notre Dame	4,998	5,097	4,416	3,867	3,866	3,738	−2	6
17	26	Ohio State U	4,931	3,846	2,904	2,870	2,355	2,679	28	13
18	42	U of Texas, Austin	4,922	2,174	3,873	3,527	2,781	3,017	126	10
19	10	U of Colorado	4,911	5,430	3,358	2,695	2,755	3,146	−10	9
20	21	Johns Hopkins U	4,903	4,155	3,783	3,604[a]	3,800	3,981	18	5
		Total, first 20 institutions	$123,764	$115,605	$101,423	$ 91,392	$ 86,302	$ 82,065	7%	9%
21	18	U of Utah	4,791	4,426	3,380	3,085	2,858	2,720	8	12
22	15	Indiana U	4,757	4,885	4,694	4,642	4,237	3,042	−3	9
23	30	Princeton U	4,575	3,104	2,892	2,642	2,485	2,142	47	16
24	16	Yale U	4,522	4,591	3,528	3,008	2,599	2,609[a]	−2	12
25	23	U of Massachusetts, Amherst	4,347	3,993	3,784	3,336	2,773	2,067	9	16
26	25	U of Oregon, main campus	4,345	3,959	3,524	2,686	2,530	1,235	10	29
27	27	U of Pittsburgh	4,045	3,836	3,343	2,833	2,188	1,581	5	21
28	29	U of Minnesota	4,013	3,295	3,346	3,345	3,377	3,494	22	3
29	32	Howard U	3,856	2,965	3,300	2,069	867	1,248	30	25
30	24	Northwestern U	3,753	3,963	3,471	3,012	2,711	2,813	−5	6
		Total, first 30 institutions	$166,983	$154,968	$135,893	$123,267	$112,927	$105,016	8%	10%
31	28	U of Maryland, College Park	3,557	3,323	2,862	2,834	3,068	2,418	7	8
32	37	Colorado State U	3,403	2,434	2,426	2,055	2,230	2,079	40	10
33	31	U of California, Irvine	3,394	3,035	2,096	1,725	1,593	1,821	12	13
34	34	U of Rochester	3,336	2,861	3,490	2,800	2,774	2,553	17	5
35	35	U of South Carolina	3,283	2,784	2,533	2,221	1,865	902[b]	18	29
36	20	Texas A&M U	3,128	4,195	2,735	3,327	2,823	2,793	−25	2
37	36	U of California, Santa Barbara	3,087	2,709	1,881	1,723	1,480	1,628	14	14
38	53	U of North Carolina, Chapel Hill	2,929	2,885	2,699	2,381	2,218	1,936	2	9
39	48	Georgia Inst. of Technology	2,914	2,051	2,227	2,032	1,800	2,030	42	7
40	44	U of Southern California	2,857	2,149	2,495	2,456	1,717	1,639	33	12
		Total, first 40 institutions	$195,359	$179,455	$158,460	$142,345	$134,495	$124,815	9%	9%
41	43	U of Virginia	2,748	2,165	2,099	1,663	1,597	1,655	27	11
42	57	Duke U	2,462	1,646	1,687	1,372	1,055[b]	924	51	22
43	77	Washington State U	2,414	1,211	682	525	na	na	99	—
44	40	U of Florida	2,368	2,302	2,042	1,325	1,341	1,156	3	15
45	41	U of Michigan	2,367	2,286	2,356	1,853	1,547	1,591	4	8
46	55	U of Arizona	2,291	1,738	1,843	1,557	1,228	1,084	32	16
47	66	Syracuse U	2,283	1,496	926	826	1,278	551	53	33
48	82	George Brown U	2,252	1,075	822	645	693	774	109	24
49	39	Arizona State U	2,218	2,306	2,014	2,124	1,996	1,956	−4	3
50	38	State U of New York, Stony Brook	2,210	2,343	2,069	1,809	1,901	2,080	−6	1
		Total, first 50 institutions	$220,491	$201,640	$178,404	$159,034	$147,131[c]	$136,588[c]	9%	10%
		NATIONAL TOTAL	$337,913	$307,214	$277,957	$247,652	$231,108[c]	$216,783[c]	10%	9%

Note: Data for institutional fiscal years. A number of institutions have developed or are in the process of developing new computer systems and methodologies that enable them to report more accurately the total cost of science and engineering research. Fiscal 1986 comparisons with data reported in earlier years may be inappropriate in some areas. a Estimated. b Imputed. c Totals do not include Washington State University, for which data are unavailable. **Source:** National Science Foundation